PRODUCT ENGINEERING

GEORGE F. NORDENHOLT, *Editor*

Switching Jobs Doesn't Spell Progress

IN THIS PERIOD of intense industrial activity and war preparations everyone will face many perplexing problems and will experience disruptions of what would be an otherwise normal course of life. Naturally, men in the manufacturing industries will be affected more than will those in other business activities, because of the more highly mechanized character of warfare, and also because of the scarcity of experienced design engineers and skilled technicians available.

Already there is felt the demand for engineers and skilled workers. Some manufacturers are offering tempting positions and wages to men who have proved their worth in other industries. "Big jobs" are opening and the specifications to fill the bill are not as stringent as in ordinary times. Good engineers will be offered jobs above their capacity, but with a big staff to support them and not too much attention to efficiency, they will be able to "get away with it." That was the common experience of the last world war.

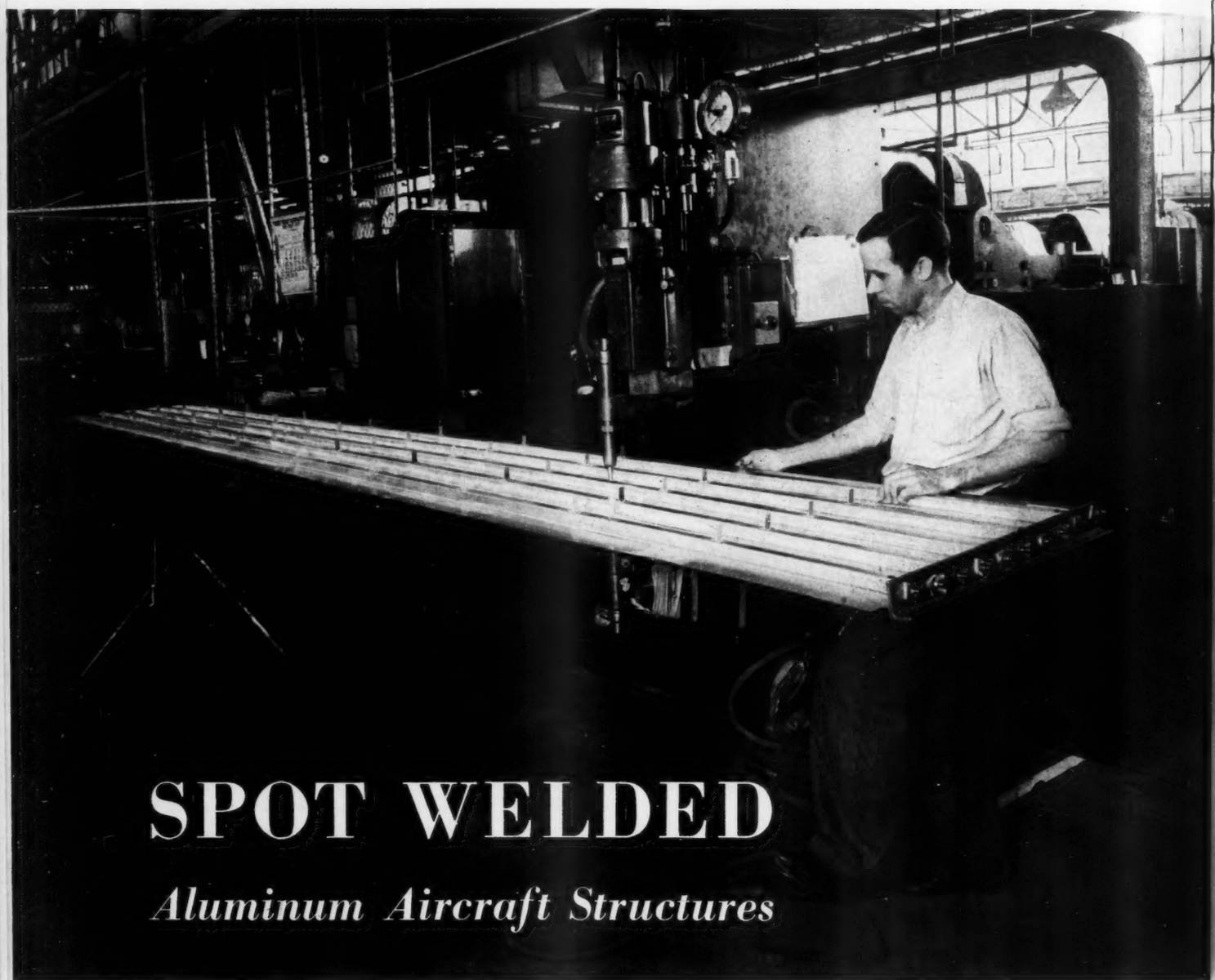
Of course, "war jobs" at "big pay" are only temporary. Nations get "sick of war" and there follows a period of such loathing of the thought of war that armaments are scrapped instead of being built. War industries vanish like the snow in a spring thaw; as the snow melts the collected dirt and filth concentrates on the surface of the slush.

In addition to the instability of "war jobs," all men engaged in war preparedness activities face another great temptation. In a time of intense activity there is a strong inclination to "do the job and let it go at that." Perhaps because of a feeling of insecurity and uncertainty, many men stop learning and growing. This condition is also fostered by the great number of specialized jobs that are created to simplify personnel requirements and speed up the work. But whatever the reason, there will be many temptations to yield to the allurements created by intense industrial activity.

Though the fields far away look greener, though a few more dollars now could well be used, and though a bigger title sounds fine, it must be remembered that in the long run the acres of diamonds are probably to be found in one's own backyard.

Naturally, there will be many new and responsible positions to be filled in the fast growing manufacturing plants. These should be applied for only by men who are really qualified to fill them. Men who properly fill such jobs should treat them not as mere tasks to be exploited for self-aggrandizement, but as opportunities for further self-development. Such men will continue uninterruptedly their steady growth to master greater responsibilities regardless of the temporary nature of their jobs. When they leave, they will be better equipped to handle successfully even bigger undertakings.

But before launching out into a job with another company, the long range opportunities of one's present connection should be studied carefully. The chances are that Dame Opportunity is beckoning or will beckon soon. After all, merely switching jobs for a few extra shekels does not spell progress. One cannot see the rocks and brambles in the apparently greener fields far away.



SPOT WELDED

Aluminum Aircraft Structures

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Strong and dependable spot welding of aluminum and aluminum alloy sheets is being done on a production basis with new types of resistance welding machines. Both Army and Navy specifications permit such welding on aircraft even for main load-carrying members.

PERHAPS the most important development in the aircraft industry for decreasing assembly costs is the spot welding of aluminum and its alloys. Although spot welding aluminum has been done for many years, it was not until four years ago when electronically controlled spot welders became available that it was possible to spot weld aluminum alloys with any assurance as to the quality of the welds. During the past year exceptional further progress has been made in the design of spot welding machines with the result that many of the principal load carrying or primary structures on airplanes are now being designed for spot welding. Indicative of the high strength, quality and uniformity now obtainable in aluminum spot welds, many highly stressed assemblies on airplanes for the U. S. Navy are fabricated by spot welding.

There are three basic types of equipment suitable for spot welding aluminum. First is the electronically controlled a.c. machine with transformers to convert the power into low voltage and high current. The second type of machine consists of charging a high capacity condenser to a preset voltage which, after a predetermined time, discharges a high intensity current to make the weld. The third type of spot welding machine suitable for aluminum alloys operates on the principle of storing the electrical energy in an induction coil. The operation may be likened to that of the ignition system in an automobile with the exception that the coil

◀*Spot welding an aluminum wing panel on a Sciaky machine*

in the welding machine is charged at comparatively high voltage and is wound so that the secondary discharges a high intensity current at low voltage.

All machines suitable for aluminum spot welding have two major adjustments, electrode pressure and the amount of electrical energy furnished per weld, or the welding heat as more commonly called. In the electronically controlled a.c. welders the duration of current flow when making the weld, or the "current-on" time, also is adjustable to any number of cycles of 60 cycle current.

In Fig. 1 are shown the current-time curves for the operation of the condenser discharge type welding machines. The amount of electrical energy used in making a weld, measured by the area under the curve, is controlled by varying the height of the curve peak which is a direct function of the charging voltage applied to the condenser. If the resistance in the secondary circuit is low, the normal discharge curve, Fig. 1 (B), has the form of a damped sinusoidal wave; but if this resistance is comparatively high, the current decreases along an exponential curve to zero, Fig. 1 (C). Still a third wave form available, Fig. 1 (D), and the one most used in this type of welding machine is that obtained by electronically shorting the condenser terminals as the current passes through zero. The total number of wave forms available with variations of the condenser discharge type machines is greater than with any other type of control at the present time.

The inductance coil type of welder current-time curves are illustrated in Fig. 2, the peak of the curve being a function of the time of charging the inductance coil at a constant voltage. The discharge curve rises instantaneously to the peak and falls off exponentially to zero at a rate inversely proportional to the amount of resistance in the secondary circuit, as indicated in Fig. 2. High resistance in the secondary causes an almost vertical drop in the voltage.

For both of the above types of machines the pressure and heat adjustments are the major factors contributing to the quality and strength of the welds. There is a welding "time" factor involved which is not nearly as important as in the a.c. type welders. In the inductance type machine the current peak, as has already been mentioned, is determined by the time of charging and up to this point is unaffected by resistance in the secondary circuit. From this point to zero along the exponential curve the duration of current flow is an inverse function of the resistance in the secondary circuit. However, as the maximum duration with no resistance is of the order of 10 cycles of 60 cycle a.c., most of the energy has been expended in the first 4 or 5 cycles of time. By increasing the resistance the total duration of current flow may be reduced to 3 or 4 cycles of time of which the first cycle may be the only part contributing greatly to forming the weld. Not as much is known of the condenser discharge type machines but in general it is safe to say that the current "peak" and wave front form are the important variables, not the time.

In the design of spot welded constructions the important considerations are the limitations in the application of the process and the specifictaions for efficient designs.

Aluminum and practically any of its alloys in common use can be spot welded to give uniformly strong and efficient joints. In general on U. S. Navy contracts 2S, 3S, 52S, 53S, 24ST Alclad, 24SO Alclad, 17ST Alclad and 17SO Alclad are spot welded to the most stringent specifications. Spot welding of the alloys 24ST, 24SO, 17ST and 17SO without the Alclading is not permitted by U. S. Navy specifications, although these alloys can be spot welded as readily and efficiently from a static strength standpoint without the Alclading. Without the Alclading, however, the spot welds tend to corrode under certain conditions and, therefore, are not permitted by the above specifications, although the degree and rapidity of this corrosion has not been fully established for welds made with the latest types of welders.

Any two aluminum alloy sheets of the same or different alloy and of the same or different thickness can be spot welded together with no great difficulty if the thickness of the thinner sheet is not more than approximately 0.125 in. and the total thickness of the two sheets is not more than 0.250 in. Three or more sheets of the same or different thickness can be spot welded together if the total thickness does not exceed 0.250 in. In any case

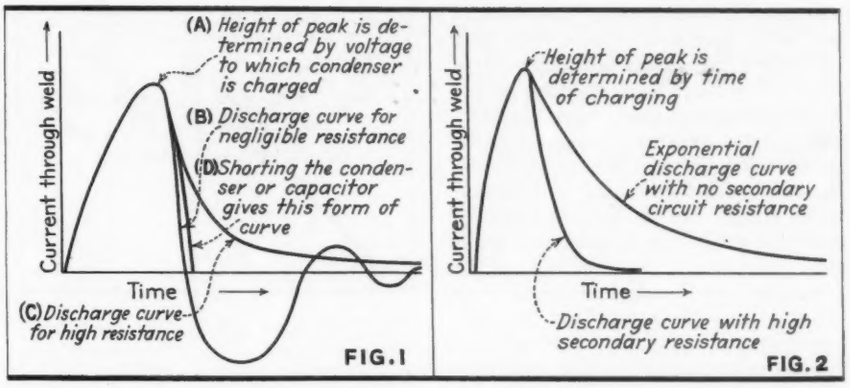

Current through weld
(A) Height of peak is determined by voltage to which condenser is charged
(B) Discharge curve for negligible resistance
(D) Shorting the condenser or capacitor gives this form of curve
Time
(C) Discharge curve for high resistance
FIG. 1
Current through weld
Height of peak is determined by time of charging
Exponential discharge curve with no secondary circuit resistance
Time
Discharge curve with high secondary resistance
FIG. 2

Fig. 1—Current-time curves for operation of condenser discharge type welding machine
Fig. 2—Current-time curves for operation of inductance coil type welding machine

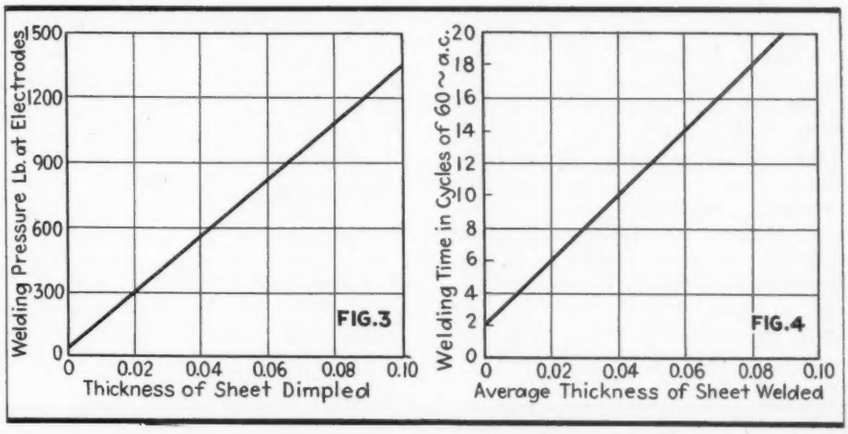


Fig. 3—Welding pressure at electrode is directly proportional to thickness of sheet in contact with upper electrode. Fig. 4—Welding time is proportional to the average thickness of the sheets being welded together

the ratio of thick to thin sheets should not be greater than 2 to 1 or 3 to 1 depending on conditions, since these figures depend to a great extent on the spot welding equipment used. Undoubtedly greater thickness of sheets can be spot welded by machines specially designed for that purpose. The limitations given here assume the use of standard welders now generally available.

As shown in Fig. 3, the welding pressure that must be exerted by the electrodes in order to make a good weld is directly proportional to the thickness of the sheet in contact with the upper electrode. This electrode has a spherical surface of $\frac{1}{2}$ in. radius which puts a slight dimple in the heavier sheet. The other sheet rests on the bottom stationary electrode which is flat leaving the sheet perfectly smooth. If two spherical electrodes or two flat electrodes are used the pressure is proportional to the thinner of the two sheets. Time and heat remaining the same, the diameter of the spot decreases with increase in welding pressure.

As shown in Fig. 4, the welding time required for a good weld is proportional to the average thickness of the sheets being welded together. The amperage or heat to make the weld is also increased with increase in sheet thickness. The diameter of the spot for a weld of adequate strength is a function of the thicknesses of the sheets being welded together, increasing as the thickness of the sheet increases. This is an important consideration as the diameter of the spot is the determining factor with reference to the strength on the spot welds and their minimum edge distance.

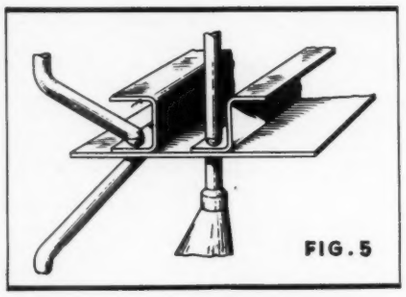


Fig. 5—In spot welding the position of the welds must be readily accessible to the electrodes. Both straight and slanted electrodes are shown here

As in all spot welding, the positions of the welds must be readily accessible to the electrodes. The most accessible positions are those which permit the use of two plain straight vertical electrodes as used when welding two flat sheets together. As shown in Fig. 5, however, it is not always necessary to sacrifice structural efficiency to maximum accessibility, the more efficient C-section being used in preference to the Z-section by welding with slanting or offset electrodes.

There is, however, a definite relation between the distance the electrodes can be slanted or cantilevered and the thickness of the sheets being welded. As explained above, the thicker the sheets the greater must be the welding pressure. This increased pressure, which causes more deflection of the electrodes and welding arms, can be partially compensated by designing the electrodes so that the deflections at the upper and lower electrode are about equal. Then when the arms deflect the spherical surface of the upper electrode will roll on the sheet instead of sliding. With increasing pressure and overhang, however, a point is reached where it is no longer possible to compensate for the deflections. When welding sheets as thin as 0.016 to 0.025 in., the "overhang" or offset of the welding electrodes may be large as compared to the amount of offset permissible when welding sheets 0.064 to 0.125 in. thick, which

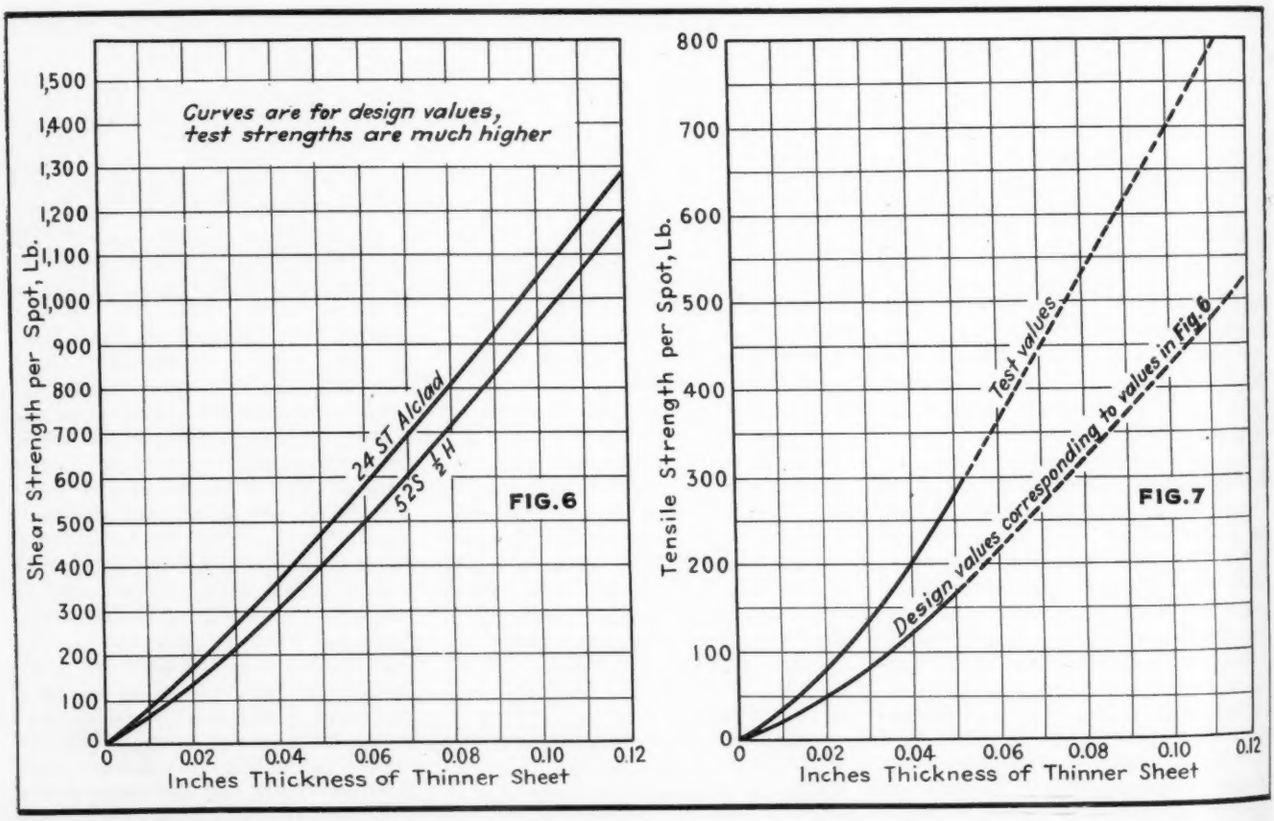


Fig. 6—Design values for shear strength of spot welds in 24ST Alclad and 52S1/2H aluminum alloy sheets

Fig. 7—Test and design values for tensile strength of spot welds in 24ST Alclad for various sheet thicknesses

require welding pressures ranging from 1,000 to 2,000 lb. or more. For such high welding pressures electrodes as nearly vertical as possible are used.

Fundamentally, spot welded joints are designed by the same general method as used in calculating the shear strength of riveted joints. Fig. 6 gives safe design values for the shear strength of spot welds in 24ST Alclad and in 52S½H aluminum alloy sheets of different thicknesses.

In general, spot welded joints should be designed so that the welds are not loaded in tension or torsion. Such design does not use the material effectively as the strength of the welds in other than shear loading is relatively low. In addition, little is known of the resistance of welds loaded in tension or in torsion to fatigue or vibratory loading. The curves in Fig. 7 give the tensile strength of spot welds in 24ST Alclad for different sheet thicknesses.

Minimum allowable distance from the center of the spot to the edge of the sheet in general may be determined by the formula:

$M = 1/8$ in. $+ 3t$

$M =$ minimun edge distance, in.

$t =$ thickness of dimpled sheets, in.

Spot welds placed too near the edge of a sheet will cause the edge to be pushed outward possibly to the point of cracking. Such a condition might, under vibration or high repeated load, cause a fatigue failure.

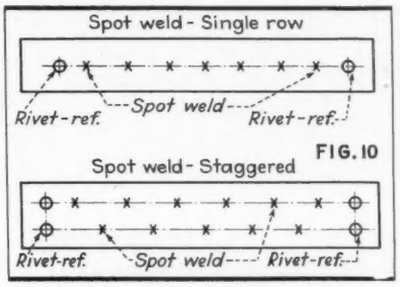


Fig. 10—Drafting symbols for spot welding used at the Vought-Sikorsky Aircraft Company. The reference rivets locate the piece for spot welding

For channels, strips and angles, the minimum dimensions that will permit efficient spot welding are given by the curves in Fig. 8 for various sheet thicknesses.

Spacing of spot welds in a single row for secondary structures, that is, assemblies which are not major structural parts of airplanes, is given by the curves in Fig. 9. For primary structures upon which depend the safety of an airplane, the spot weld spacing in a single row should be as follows:

Thickness of Thinner Sheet	Spot Spacing Tol. ± 1/8 in.
Less than 0.064 in.	1/2 in.
0.064 – 0.091 in.	5/8 in.
0.091 – 0.125 in.	3/4 in.

In general, for two or more rows of spots in a secondary structure the spacing in each row should be 1.5 times the spacing between rows, the minimum spacing between rows being the same as the spacing between spots, as given by Fig. 9. The spacing between rows should not exceed 1-1/8 in., as greater spacing might result in slight buckles in the sheet between spots.

In primary structures the distance between rows of spots in reinforcing strips containing two or more rows of welds should be 1 in. For the spacing between spots in each row add 1/8 in. to the values given in the above table.

Drafting symbols used at the Vought-Sikorsky plant for spot welding are shown in Fig. 10. As shown, two or more rivets are usually provided to locate the pieces to be welded. In prac-

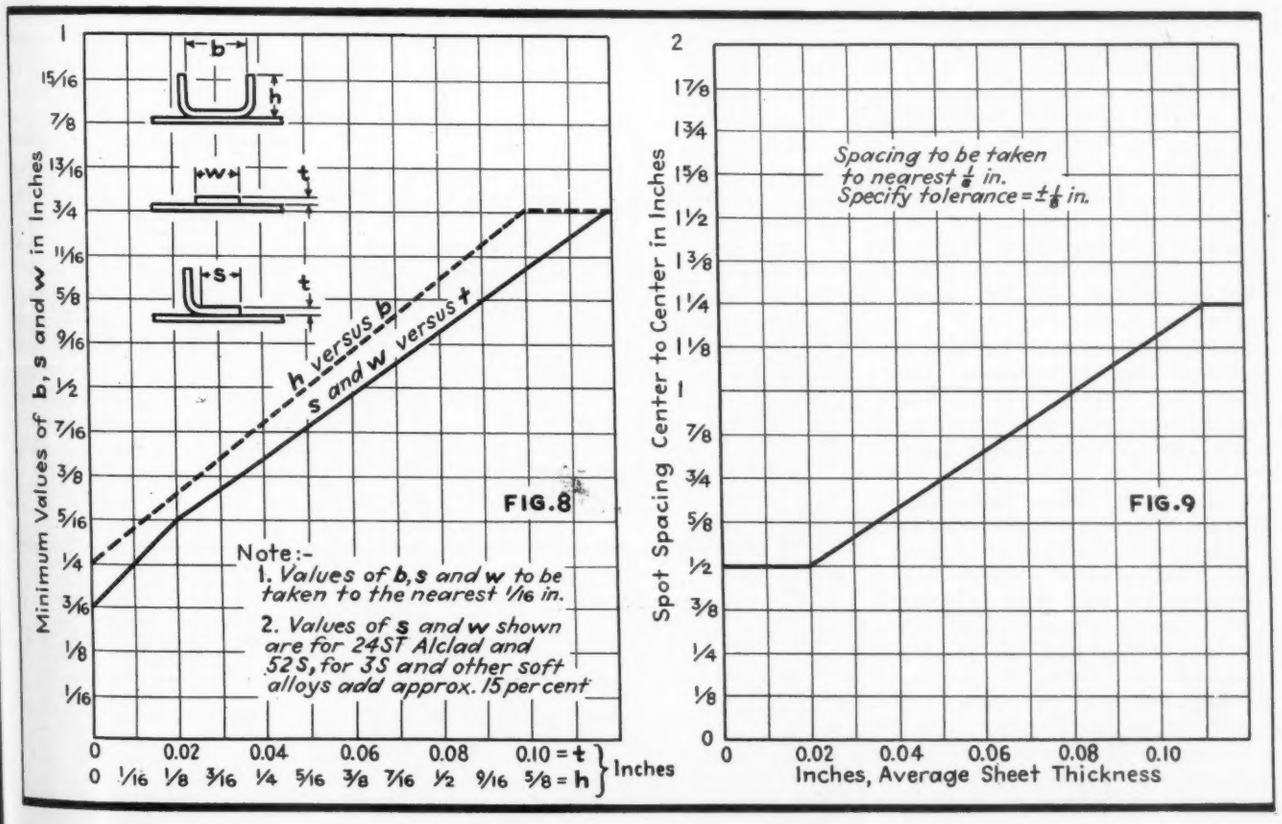

Minimum Values of b, s and w in Inches
b
h
w
t
s
t
h versus b
s and w versus t
FIG. 8
Note:-
1. Values of b, s and w to be taken to the nearest 1/16 in.
2. Values of s and w shown are for 24ST Alclad and 52S, for 3S and other soft alloys add approx. 15 per cent
0 0.02 0.04 0.06 0.08 0.10 = t
0 1/16 1/8 3/16 1/4 5/16 3/8 7/16 1/2 9/16 5/8 = h
Inches
Spot Spacing Center to Center in Inches
Spacing to be taken to nearest 1/8 in.
Specify tolerance = ± 1/8 in.
FIG. 9
0 0.02 0.04 0.06 0.08 0.10
Inches, Average Sheet Thickness

Fig. 8—Minimum dimensions for efficient spot welding for aluminum alloys of various sheet thicknesses

Fig. 9—Spacing of spot welds in single row for assemblies that are not major structural parts of airplanes

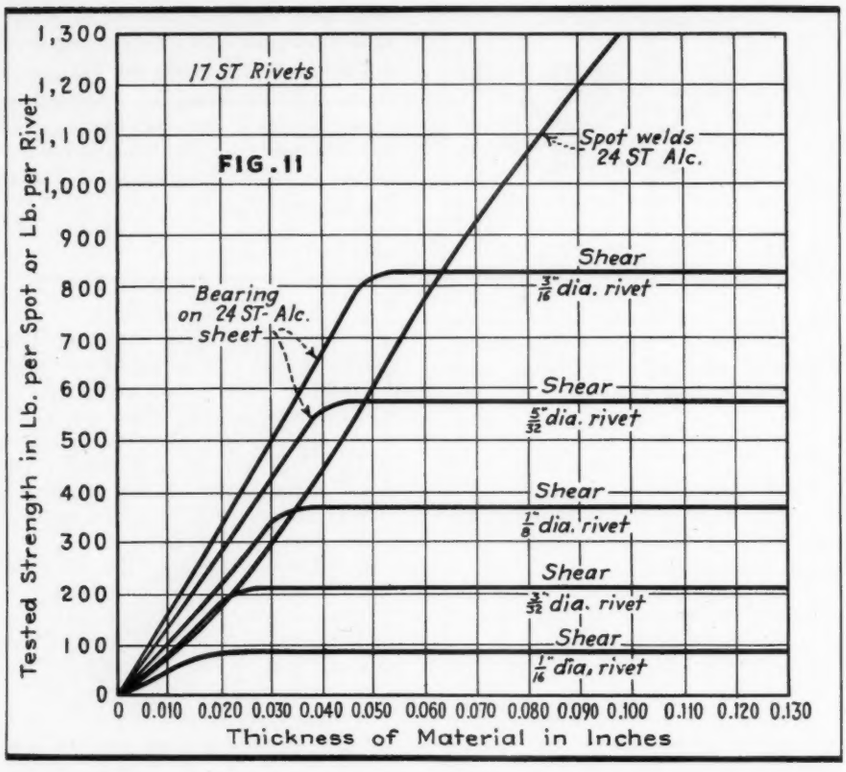


Fig. 11—Test strengths of spot welds and rivets for various thicknesses of material

tice holes are drilled and temporary clamps inserted to hold the parts in correct relative positions. After spot welding, rivets or screws are put in the holes. Rivets are usually placed at the ends of the long line of spots in a load carrying structural assembly so that the welds will not be subjected to tension if the ends of the sheets tend to pull away because of air loads.

In the process of spot welding the metal immediately surrounding the spot expands because of the heat and then contracts upon cooling. This contraction is more than the expansion, and hence the sheet shrinks slightly. On a short piece this is not usually noticeable and causes no difficulty, but when large areas of flat sheets are spot welded, buckling often occurs. Similarly, a row of welds along the edge of a long sheet generally causes buckling or a wavy edge.

Buckling of a large spot welded panel can be prevented by rolling each row of spots immediately after the row has been welded. Although this cannot always be done, it has proved effective for large flat panels with "hat" section reinforcing strips.

To prevent the edge of a sheet from buckling after being spot welded, the edge of the sheet is bent in a right angle to form a reinforcing flange or leg. After the welding has been finished the flange may be trimmed.

Frequently the question is asked: "What is the comparison between the shear strength of a rivet and that of a weld?" The answer is shown graphically in Fig. 11. It must be considered that a riveted connection may fail by crushing of the sheet, which factor limits the maximum diameter of rivet that can be used effectively in a sheet of given thickness.

There are three typical defects to be found in spot welds if the correct welding technique is not followed. These are illustrated and explained in Fig. 12. Such defects are rare in production because the welding machine after having been adjusted properly should duplicate the same quality welds indefinitely.

In order to establish an inspection control governing the strength and quality of spot welding performed on production assemblies a definite procedure has been established. For given sheets to be welded, the proper welding pressure and time have been well founded, as given in the curves in Figs. 3 and 4. Before welding and after setting a machine to the correct time and pressure, a tentative "heat-setting" is made and a double spot test specimen is made of the sheets to be welded. This is then pulled in a small hand-operated portable testing machine to determine the shear strength of the welds. If necessary the "heat-setting" is readjusted until the test shows the proper shear strength of weld.

Several simple precautions should be specified regarding the condition of the surfaces to be welded. Both sides of the sheets where the welding is to be done should be thoroughly cleaned with acetone or similar substance to remove all grease, oil and paint. The surfaces that will come in contact with the electrodes should then be wire brushed to be slightly roughened and to remove the thin film of highly electrical resistant aluminum oxide. Best results are obtained when the cleaned surfaces are allowed to stand a few hours to reform a slight amount of oxide. If the surface is too clean, the aluminum has a tendency to alloy with the electrode.

In lieu of the above procedure the complete assembly may be cleaned by etching in a suitable reagent and rinsing thoroughly before welding. No entirely satisfactory solution has been found for producing the desired result.

What has been written here by no means tells the whole story of the spot welding of aluminum and its alloys. Progress during the past year or two has been extraordinarily rapid, partly because of research and partly because of the better welding machines now available. The result has been many primary structures in airplanes now being spot welded, making possible weight saving, cleaner construction and more rapid production.

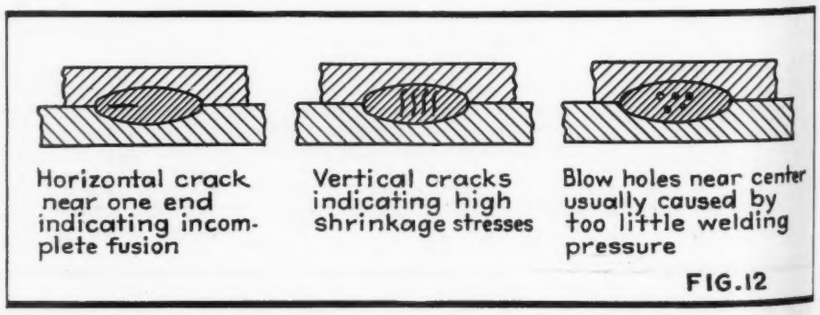
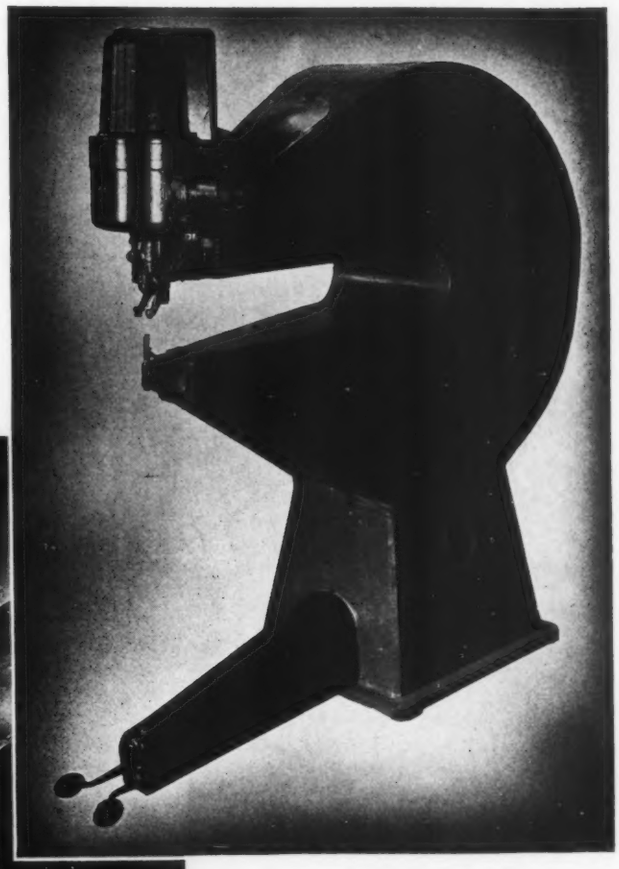

Horizontal crack near one end indicating incomplete fusion
Vertical cracks indicating high shrinkage stresses
Blow holes near center usually caused by too little welding pressure
FIG. 12

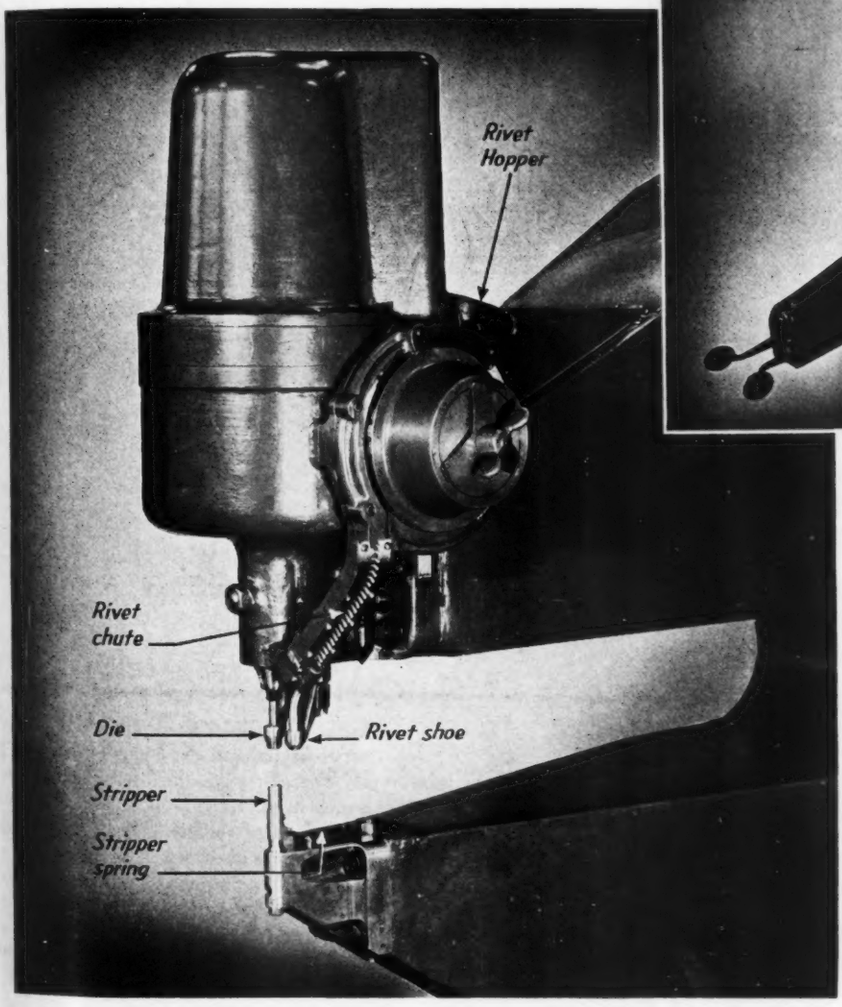
Fig. 12—Typical defects in spot welds if correct welding technique is not followed

Modern Designs

Punches Work, Feeds and Heads Rivets

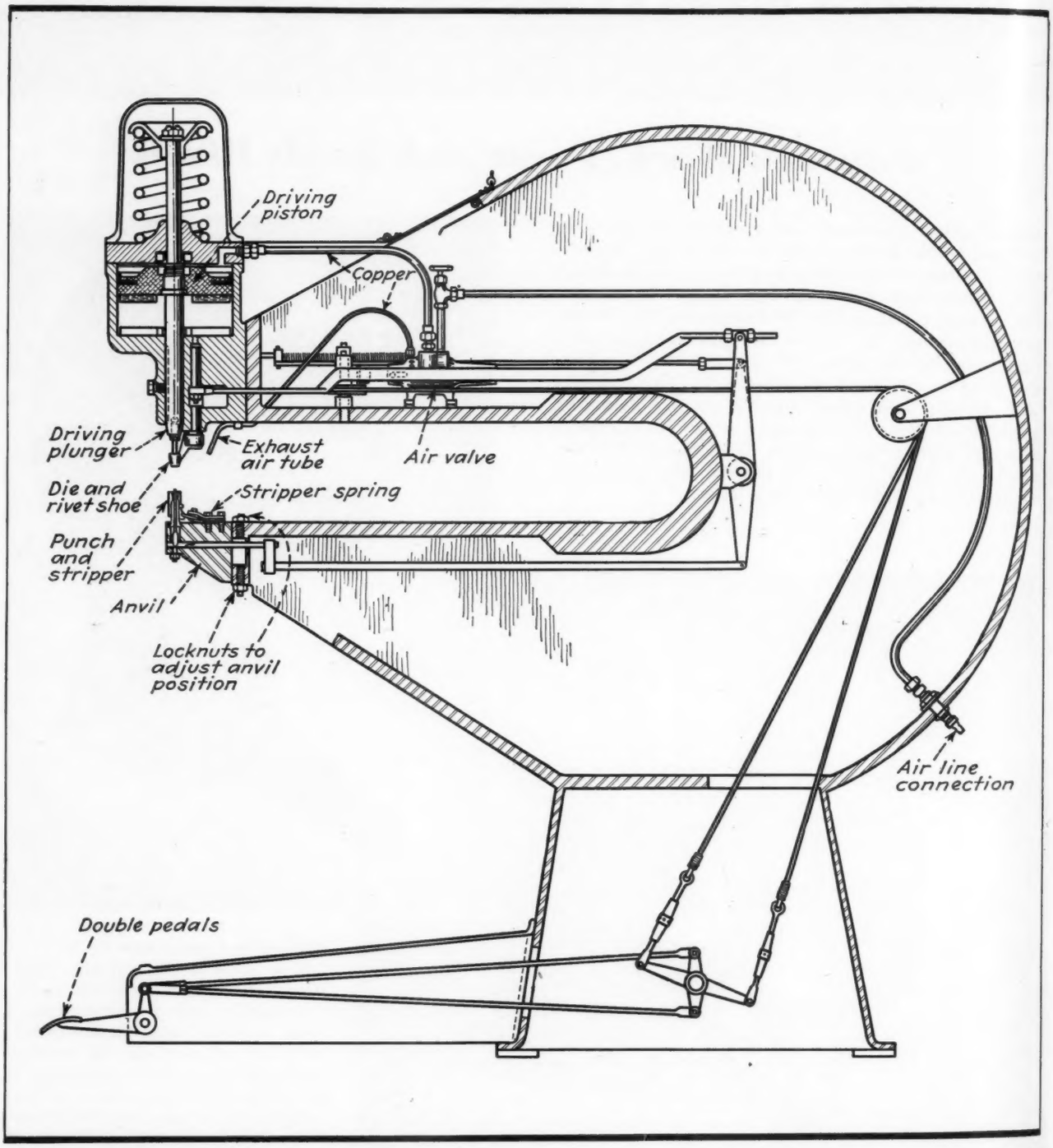
Combination punching and riveting machine, developed by the Engineering and Research Corporation, punches holes, feeds and drives rivets. Power is obtained through an air cylinder which actuates the driving plunger. The first stroke of the driving plunger swings the die to the punching position and punches the hole; the second stroke places the rivet in the work and heads it. The machine will handle solid and tubular rivets, including countersink types. Connections to air line through a 3/8 in. pipe or hose are made at the rear of the machine. Each stroke of the driving plunger is controlled by individual foot lever.





Rivet feed mechanism. Rivets are placed in the hopper, and tumbled by a drum which passes those with heads all pointing in the same direction to the chute. At the bottom of the chute, a slide synchronized with the automatic cycle, described on the next page, selects one rivet which at the proper time drops through a tube into the rivet shoe. Air cylinder is controlled by a pedal-operated valve. As the pedals are depressed, the first part of the stroke places the die and the rivet shoe in their respective positions; as the pedal is depressed further the air valve opens, forcing the driving plunger downward, thus punching the work, driving and heading the rivet. Rivet head dimension is controlled by length of rivet and position of anvil, adjustably mounted on lower arm. (*Continued on next page*)

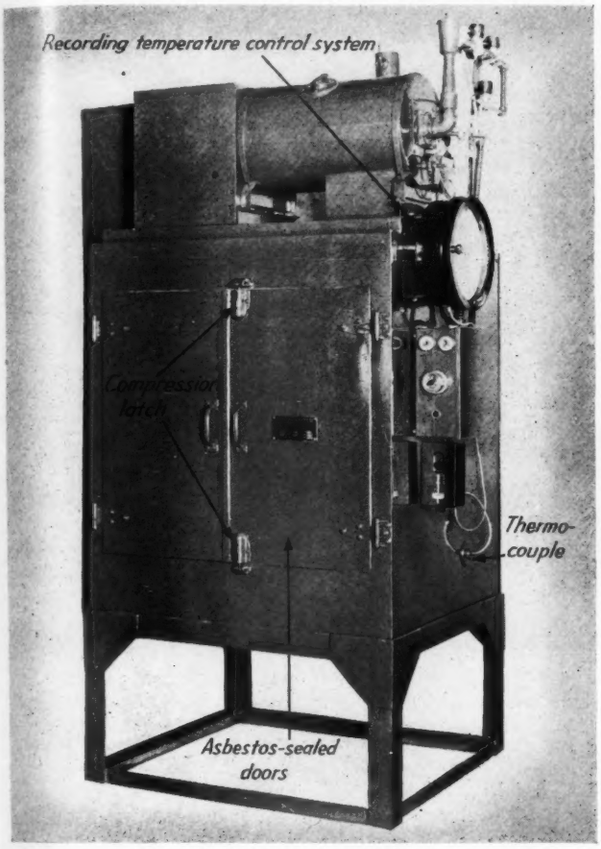
MODERN DESIGNS – Combination Punch and Riveter *(Continued)*

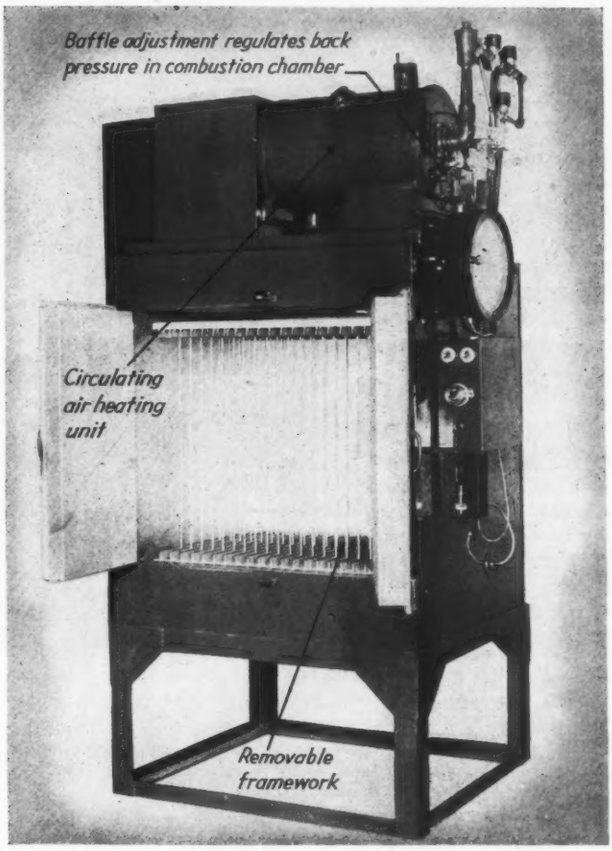


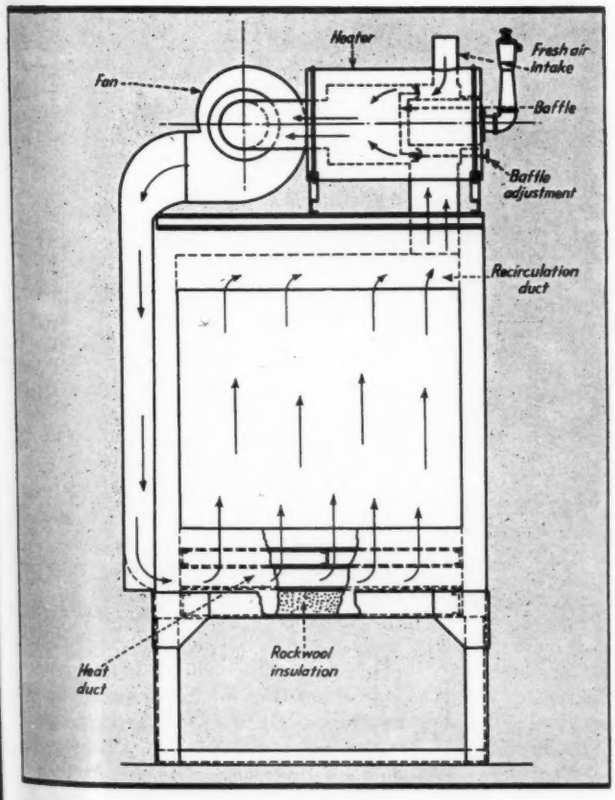
When left pedal is depressed, the punch is raised to the punching position in the anvil, and the shifter arm, carrying the die, swings to align with the center line of the punch. This releases the air valve, forcing the piston and the piston rod extension down onto the die and carrying the die down onto the work, depressing the stripper and forcing the punch through the layers of metal. Release of foot pedal causes spring to return piston to top of cylinder.

Upon depressing the right foot pedal, the shifter arm carrying the rivet shoe is aligned with the center line of punch. This again releases the air valve, the piston rod extension descends, contacting the rivet shoe and carrying it down until it centers on the punch which projects slightly through the work. The rivet shoe stops before touching the work, but the piston pushes the rivet, which is held in the spring-closed split die shoe, through the die shoe onto the punch and on through the hole. At the time the rivet shoe is indexed, the punch lift is also withdrawn. The punch drops as soon as it is pushed out of the hole, to make room for the rivet head which is formed by the further descent of the piston. A positive stop sets the desired height of rivet head.

Controlled Combustion in New Tempering Oven







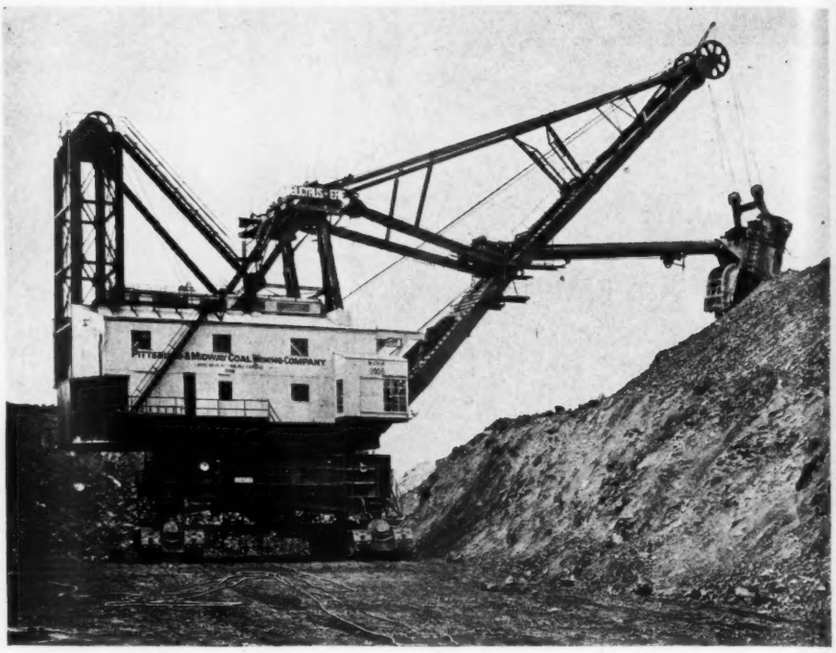
Designed for tempering and drawing coils of band-saw blades, this Despatch furnace has a top-mounted air heating unit fitted with a high-capacity fan. Heated air is circulated vertically. Wall construction varies with maximum temperature rating of furnace: for 850 deg. F. outer wall is 18 gage steel, inner wall is 16 gage steel, with 5 in. of rock-wool insulation; for 1,200 deg. F. rockwool insulation 6 in. thick is used between walls. Furnace is fitted with an asbestos door seal and compression-type explosion latches.

Heater burner is interconnected with primary and secondary combustion chamber. Hot products of combustion are diffused by an adjustable back pressure baffle, and diluted by recirculating fresh air. The resulting mixture, heated to proper temperature, is then taken by an air circulating fan and forced into oven, dryer, and furnace ducts. The positive induced draft is always under definite control. The amount of recirculating air taken into the heater is varied with independent dampers. All recirculated air entering heater must wipe the outside of the hot combustion chamber, thus being partially heated before mixing with the combustion gases.

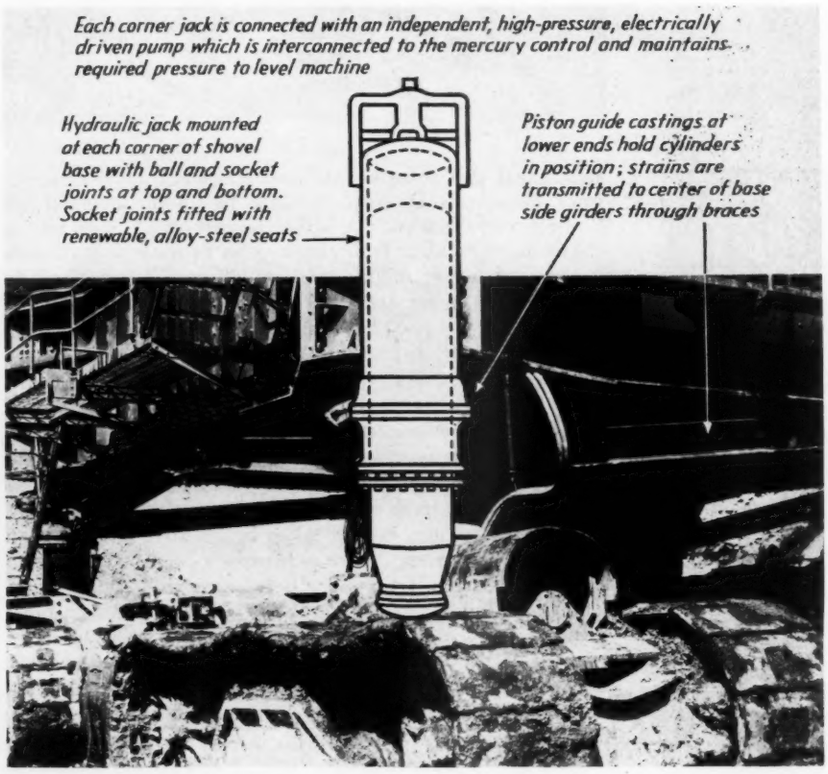
By standardizing on three sizes of frames all having the same design characteristics, and utilizing interchangeable parts wherever possible, spot welding machines are now manufactured on a mass production basis by the American Electric Fusion Corporation. With three frame sizes, the standardized line ranges in capacity from 10 to 50 KVA.

MODERN DESIGNS – Four Switches Level 33-Yd. Shovel

In the Bucyrus-Erie 950-B caterpillar mounted shovel, a hydraulic system of automatic leveling and steering handles the machine under all digging and moving conditions. Since the working weight of the machine is 2,500,000 lb., the shovel is supported on four independent caterpillar supports, one under each corner. Thus means of keeping the platform level automatically were required. Further, the machine, while moving, had to have 3-point support.



Leveling equipment, patented, consists of four hydraulic jacks, one mounted in each of the four corners of the base, an electrically driven hydraulic pump, solenoid-operated valves and a sump for oil storage. The pump and valves are controlled by a master leveling unit and the necessary relays.

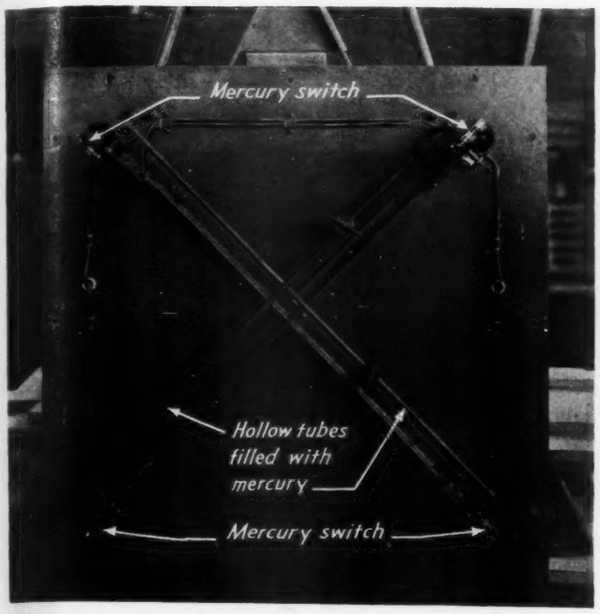

Each corner jack is connected with an independent, high-pressure, electrically driven pump which is interconnected to the mercury control and maintains required pressure to level machine
Hydraulic jack mounted at each corner of shovel base with ball and socket joints at top and bottom. Socket joints fitted with renewable, alloy-steel seats
Piston guide castings at lower ends hold cylinders in position; strains are transmitted to center of base side girders through braces

Caterpillar unit and a hydraulic jack are mounted under each of the four corners. The jacks form the connection between the caterpillar and machine base and are rated at 2,500 lb. per sq.in. pressure. Each of the cylinders is connected directly to the solenoid-operated piston valves; these are controlled directly by the master leveling unit and control relays, which are the primary control of the flow of oil into and out of each cylinder.

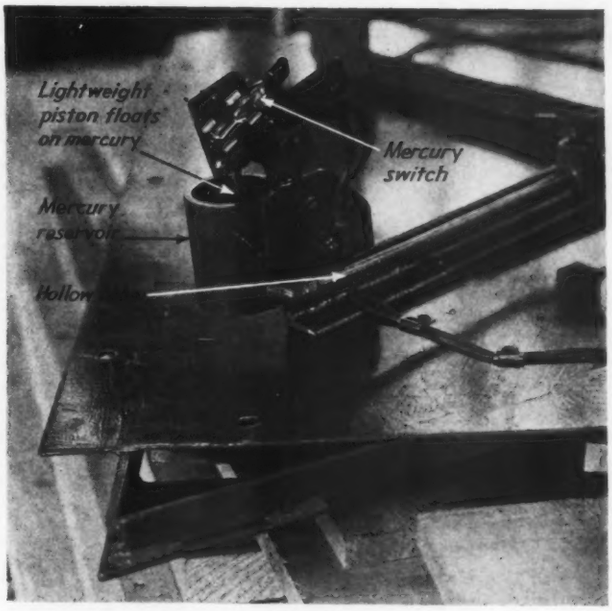
Control gives "extended leveling," that is, if the piston in one hydraulic cylinder reaches a fully contracted or fully extended position, the control will function to adjust the position of other pistons and continue leveling until the entire machine is level or until a mechanical limit is reached. Extended leveling is obtained by placing two limit switches on each hydraulic jack; one which operates when the piston reaches the fully extended position and the other which operates at the fully contracted position.

Specially designed pressure switches function in case the pressure in any one jack drops. This often happens when one caterpillar sinks into the ground, thereby causing a tendency for one corner of the base to raise off the jack, and the entire load to be carried by three jacks. In this case a pressure switch energizes the control and enough oil is pumped into the jack to cause all four corners to carry load. Pressure is not equal in all four jacks when the center of gravity is not located at the center of the machine.

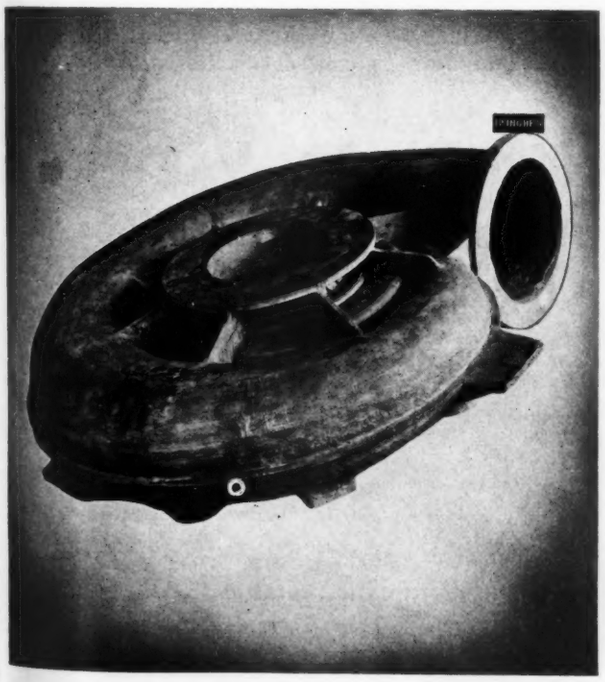
The automatic leveling equipment is inoperative when the excavator is being propelled, but the control is arranged so that two jacks on one side of the machine have valves closed, while the two on the opposite side are interconnected to allow a free flow of oil between them. This creates in effect a 3-point suspension for the machine when travelling.



Master leveling unit consists of four mercury-filled cylinders, each connected by tubing to one diagonally opposite. Each cylinder is partially filled with mercury on which floats a light weight piston directly connected to a lever mechanism on which a mercury switch is mounted. The unit is suspended from the base of the excavator by three rods. This connection absorbs high frequency vibrations in the horizontal plane which might otherwise be transmitted to the unit and cause false operation of the control. Vertical vibrations are damped by rubber mountings. The unit is patented.



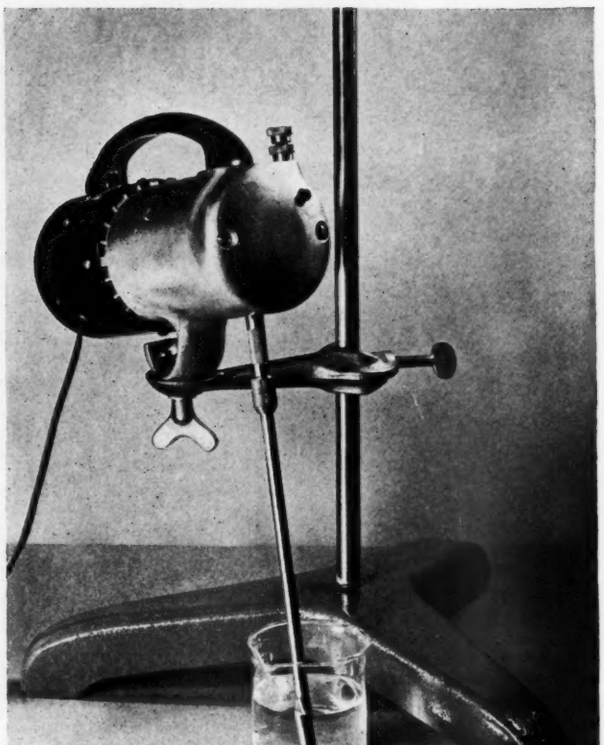
Mercury cylinders are mounted at the ends of two short "diagonals" that are parallel to the diagonals of the machine base. The plane of the master leveling unit is always parallel to the plane of the base; therefore, if one corner is lower than another, mercury will travel from cylinder to cylinder, cause the lever mechanism to tilt the mercury switch and close the control circuit. The excavator is maintained level to a fraction of a degree. To obtain sufficient angular movement to operate the mercury switches, this angle is amplified by a lever mechanism on which the switch is mounted.

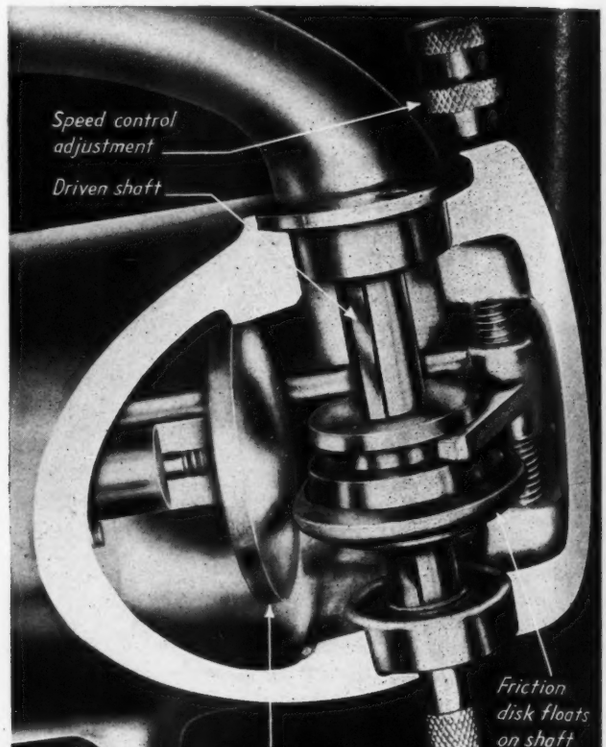


Spiral casing of hydroelectric turbine for the Shasta power plant of the U. S. Department of the Interior. This one-piece cast steel casing weighs 21.575 lb. and was built for the government by Commercial Steel Casting Company.

One-piece cast steel impeller for this turbine weighs 13,250 lb., was also produced by Commercial Steel Casting Company. Cast steel construction was used to insure rigidity so as to maintain correct curvature with relation to hub.

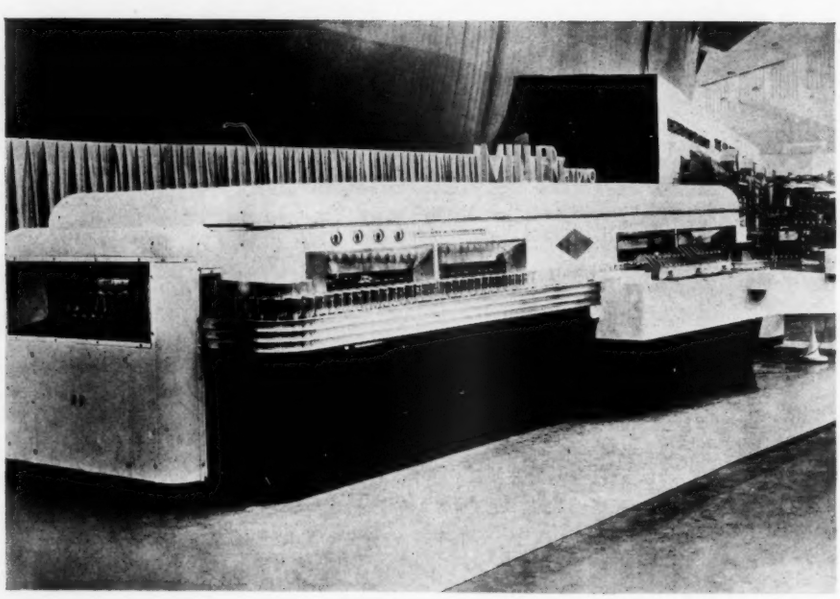
MODERN DESIGNS – Friction Disks Replace Rheostat



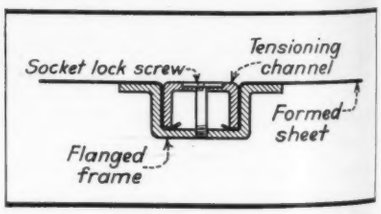


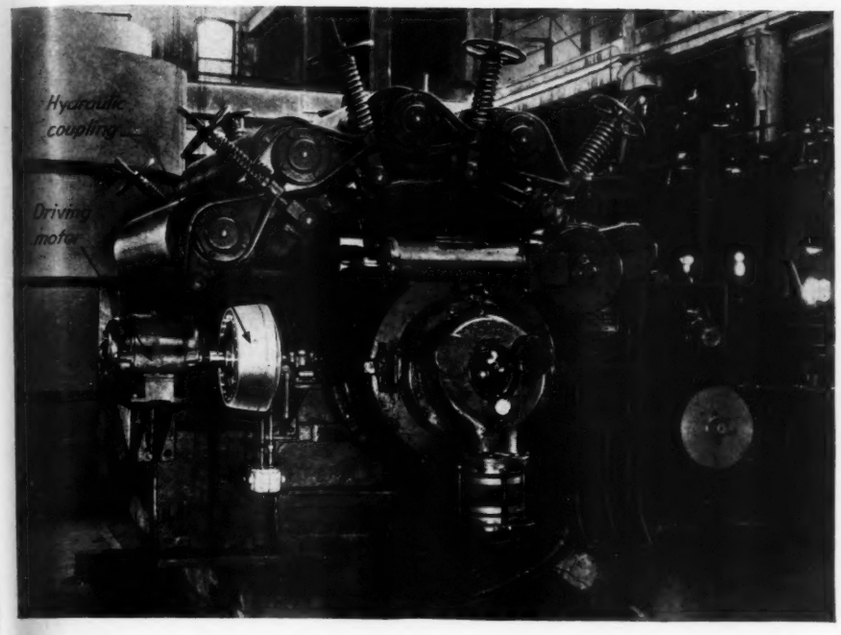
Thumbscrew adjustment of driven disk provides speed range of 250–1,750 r.p.m. in the model *F* "Lightnin" mixer. Driven shaft is mounted on ball bearings. Drive is totally inclosed; it is powered by a 1/30 hp., shaded-pole, Redmond motor. Housing is cooled by a built-in fan. Shaft and propeller are furnished in either 18–8 or monel metal. Developed by the Mixing Equipment Company, this portable mixer weighs 10 lb. complete, operates on 110 v. supply.

New Structural Assembly for Washer Housing



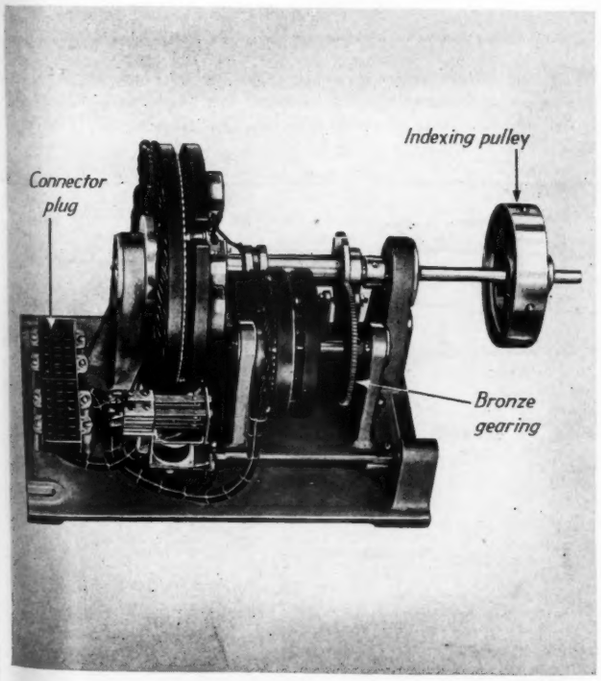
Lindsay structure, a method of assembling sheet metal and framing is now being used in the Miller Hydro Company's bottle washers and sterilizers. The sheet panels are held in place by special U-shaped members which lie flush with the outer surface and give a smooth, stream-lined appearance. In assembly, tightening of the screws which hold the U-members draws down the four edges of the panels thus putting the sheets in tension. This structure makes a light-weight, housing of great stiffness.



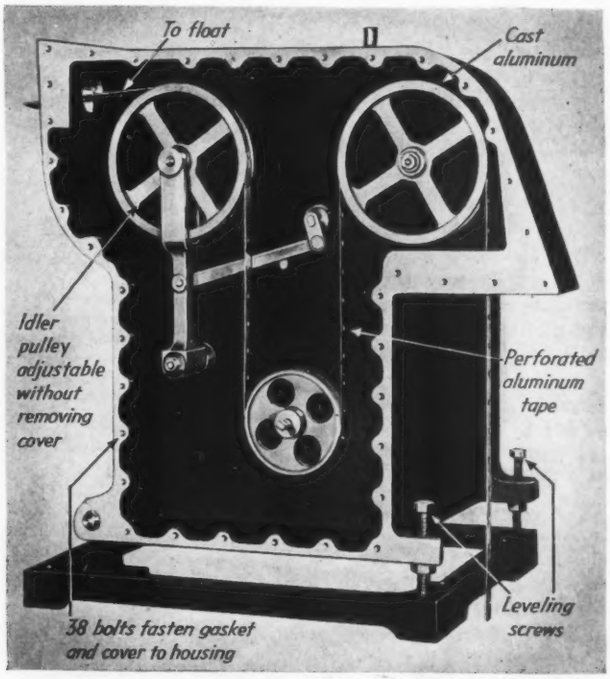


Adjustable speed drive for the rotating screen cylinder of vacuum filters is obtained by Sherbrooke Machineries, Limited, through use of American Blower hydraulic coupling in which regulation of output speed is by means of a float valve in filter tank which actuates the scoop control arm. For operation and design data on this type coupling see P. E. January 1940, page 10.

Based on accelerated test results to determine wear, Tenite II was selected in preference to hard bronze, cold-rolled steel, polystyrene and methyl methacrylate for the nozzles in Crane pumps manufactured by Pomona Pump Company. In test, the five nozzles were connected to manifolds and a common header, and a water velocity of 100 ft. per sec. was applied. The accelerated tests were claimed to be practically equivalent to five years normal operation.



Remote reading liquid level gage developed by Guardian Electric Company. Perforated aluminum tape connected to float and bridle assembly drives index pulley. Studs on pulley match perforations, preventing tape slip. Pulley drives inch and foot measuring disks fitted with contacts which close circuit to appropriate figures on indicator panel.



Pulley compartment runs in transformer oil, and gaging tape is cleaned of sediment as it passes through to counterweight well. Adjustable idler pulley permits minor corrections of gage level, up to 1 in. plus or minus, without removing cover. Tank head is ¼ in. thick casting of special aluminum alloy, finished with acid-resistant red enamel.

TAPERED TUBING

Design Possibilities for More Efficient Construction

IN the past designers had difficulty in securing the maximum structural efficiency theoretically possible in the use of tubular members. Where tubes forming the chord members of a truss were varied in size according to the loads in the individual bays, complicated joints were required which involved more difficult and costlier production. A constant-strength beam, the optimum in efficiency from the strength-weight standpoint, could only be approximated by telescoping two or more tubes and joining them with rivets or bolts. If joined by welding some slight improvement in stress distribution was achieved by "scarfing" to obtain a more gradual change in area. In designing columns to take compression end loads the designer had to compromise between a tube of maximum efficiency at the center and one that was most suitable for making a practical joint at the ends.

When step-tapered tubing, the thickness of which remains constant while the outside diameter is increased or decreased in steps, became available it offered a change in area along the length of a member without the necessity of making riveted or welded joints. This was of advantage, particularly in the aircraft industry, where production costs are generally secondary to weight saving. In selecting the chord members of a fuselage truss it was formerly necessary to choose between the production advantage obtained with a tube of sufficient size to use over several bays or the design advantage obtained by varying the tube size according to the load in the individual bays.

An example of a tubular cantilever beam is an airplane control stick, designed to transmit an applied load at the hand grip at the top, see Fig. 1. The lower end of the stick may be of any practical size but the upper end is limited to a size which will take the standard size hand grip. A common solution is to telescope members in order to change the gage rather than the diameter at the highly stressed points. To accomplish this with straight tubing is difficult since the proper gages for telescoping are ordinarily not available in all tubing sizes. For example, a 2 in.-0.058 in. tube (a standard aircraft gage) will take a telescoping 1⅞ in. tube of any wall thickness but a 2 in.-0.065 in. tube will not. Moreover, since in the series of tube sizes diameters vary by ⅛ in., in all normal sizes only an 0.058 or a 0.120 in. wall thickness is suitable for reinforcing use, the tubes available do not provide the variation in gage desired. To get a proper fit it is necessary either to turn down or to swage the internal reinforcing. Furthermore, the use of such reinforcing is not effective or efficient since the necessary transition of load at the end of the reinforcing cannot be easily or economically accomplished and constitutes a source of weakness. Based on pure theory the ideal solution to the control stick problem or to any tubular beam design would be a tube, the section properties of which could be varied uniformly along the length.

A near approach to the desired theo-

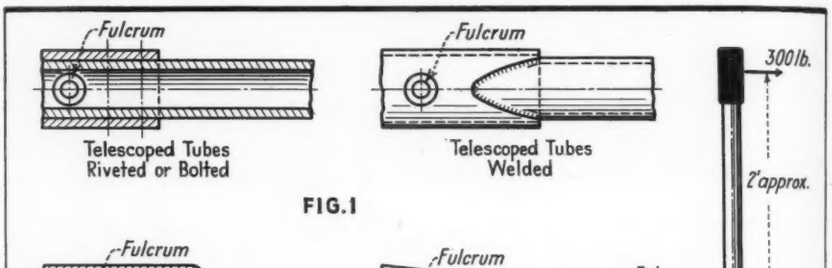


Fig. 1—Methods of making cantilever tubular beams when weight saving is a consideration include telescoping tubes, step-tapered tubing, and tapered tubing. The latter two have possibilities for reducing costs by eliminating riveting

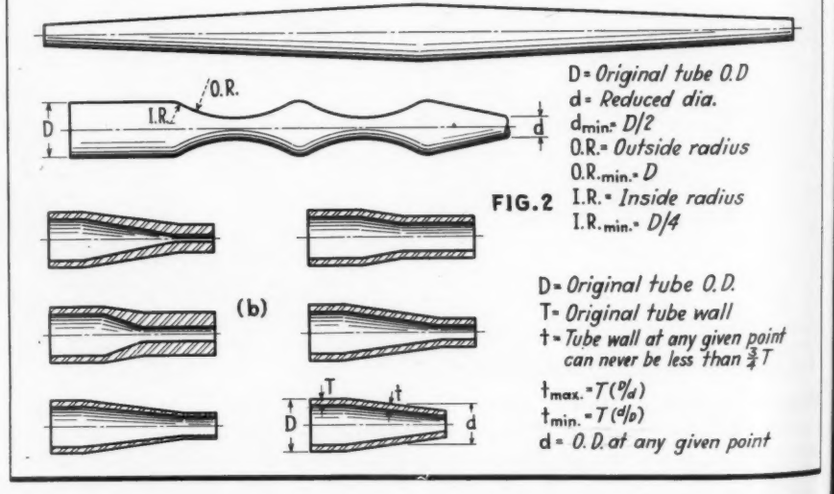


Fig. 2—Dimensional ratios of wall thickness and diameter that are obtainable in shaped and tapered tubing

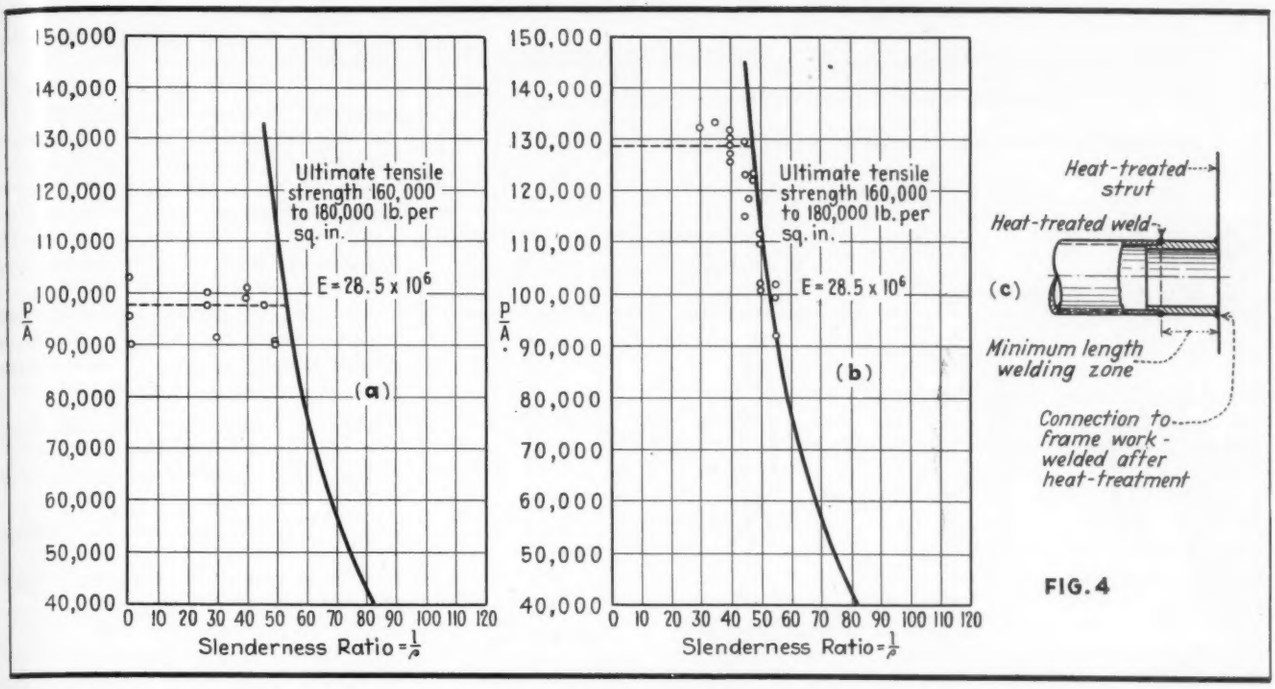


Fig. 4—Effect of increased wall thickness at the end of the tube on column strength is indicated by (a) results of tests on plain end tubes, and (b) of columns built up as shown in (c) by welding on a heavier section at the end

retical solution is now furnished by the new process for shaping and tapering tubing. The process makes possible taper either in O. D., wall thickness or both. Of advantage in column design is the fact that "double" tapers are possible, since the tube can be tapered uniformly toward both ends from the basic O.D. Also the wall thickness in double taper type tubes as large as 4 in. in dia. can be uniformly maintained.

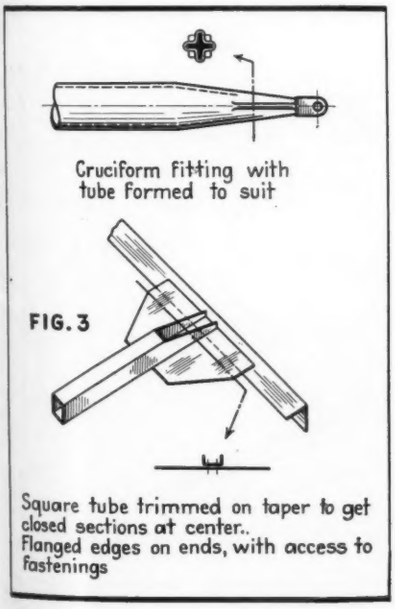

Cruciform fitting with tube formed to suit
FIG. 3
Square tube trimmed on taper to get closed sections at center..
Flanged edges on ends, with access to fastenings

Fig. 3—Difficult end connections when tubular members are not tapered

Limitations in dimensional variations and some possibilities in contour and appearance are shown in Fig. 2. A 1-in. dia. tube can be reduced about 0.60 in. without damage to the material. Similarly a 4-in. dia. tube can be reduced to approximately 2.5 in. at the small end. In general, reductions up to 40 per cent of the base O. D. can be made. The tubes can be fabricated in any length up to 20 ft. which is sufficient for most design requirements.

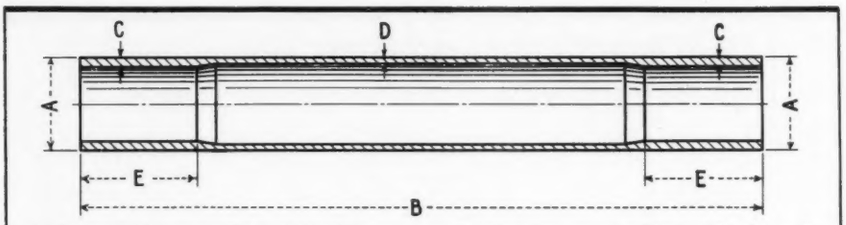
Tubing of this type has several design and production possibilities: (1) improved appearance; (2) weight saving because material is distributed according to load requirements; (3) low production costs because the amount of riveting or welding is reduced; (4) wall thickness at the end of a column can be increased to accomodate bearing loads, which is particularly advantageous where bolts or rivets are used at the joints; (5) wall thickness of members converging at joint can be made uniform thus avoiding the burning which would take place in welding if some members were thinner than others.

One general use of tubing is as a column under end compression load. A consideration of the theories involved in the design of columns will indicate the possibilities of weight saving and improved production with tubes of varying O.D. or wall thickness; important in the aircraft industry.

In the design of round tubular columns several factors are generally considered such as elastic properties, slenderness ratio, section properties at the mid-point, and the effects of conditions which may weaken the ends such as the presence of welds or rivets. The section properties at the end, however, will ordinarily be designed according to the area required for compressive and bearing strength. From this it follows that the most effectively designed column would have a large O. D. and a minimum wall thickness at the center, with a reduced O.D. and increased thickness at the end.

In many structures columns fall in the short column range or in the transition range between short and long columns. When this condition exists unit strength is more important than the slenderness ratio and higher allowable loads can be obtained by heat-treating the main portion of the tubes. The gain in column strength is limited by the degree to which the ends are reduced in strength by the presence of the welding (unheat-treated) which is normally used in aircraft to fasten the column in place.

With tubes of uniformly large diameter along their whole length, the end connections are always difficult to design and are usually heavy and expensive. Failures usually occur here until a suitable joint is developed. Fig. 3 shows two examples of end connections which indicate the difficulties and pos-



A. *Ranges up to approx. 2 in. outside diam.*
B. *24 Ft. max.*
C. *80 to 90 per cent greater than D*
D. *Approx. range 0.049 to 0.095 in. wall*
E. *As required*

FIG. 5

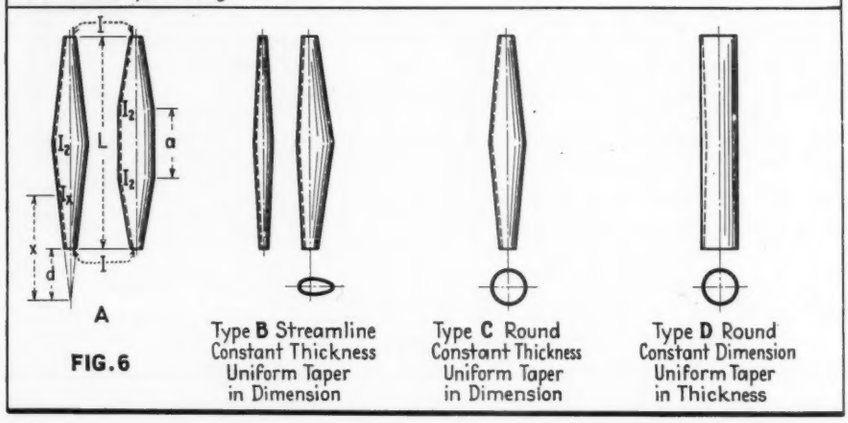


FIG. 6

Fig. 5—Heavy end tubes can be produced to these tolerances. Increase in weld area at end does not add much to the weight of the member. Fig. 6—Theoretical possibilities of columns B, C and D for weight saving and drag reduction (in aircraft) are shown in Figs. 7 and 8. All are of the general type shown schematically at A

sible expense involved. The use of tapered diameter and increased gage tubing overcomes some of these difficulties. The reduction in diameter of the tube as it approaches the end which enters the fitting will result in no appreciable loss of strength at the end connection (provided the allowable stress for the material is not exceeded) or change in the elastic behavior, if the reduced length is a small part of the total length of the strut.

If a steel tubular column of reduced wall thickness at the center and of increased wall thickness at the end is heat-treated before welding into place, the thicker ends can be proportioned so as to be greater in strength than the heat-treated center portion which is unaffected by the welding. Although the allowable unit compressive stress at the ends is less than at the center because of the unheat-treated welding, the area is so greatly increased that the product of allowable stress times area is greater at the end than at the center of the column. The practical gain that can be achieved by such a method is shown by comparative test data on standard tubular columns, Fig. 4(*a*), and on columns with increased gage at the end, Fig. 4(*b*), constructed as shown in Fig. 4(*c*). With tubing having thickened ends production costs can be reduced by eliminating the joint between the thinner and heavier gages. Fig. 5 shows the dimensions which can be obtained in tubes of uniform wall thickness in the center portion and heavier gage at the ends.

In the Euler column range, columns of high slenderness ratio can be designed to be more efficient by taking advantage of tapering. Some idea of the possible saving in weight for tapered tubes in the Euler range is given by considering the theoretical possibilities of the three types of columns shown in Fig. 6. Each of these are of the general type shown in Fig. 6(A). Figs. 7 and 8 show the results of a study made with the dimension *a* varying from 0 up to 0.8 lengths of the tube. When making this study the taper for each type was assumed linear from the point of the start of the taper to the ends of the strut.

When d = length of truncated taper end as shown in Fig. 6(A)
a = length of straight portion of tube
P = buckling load of column
L = length of column
m = function depending upon the geometry of the column
E = Young's modulus
I_2 = moment inertia of cross section of column at the large end of taper
n = exponential factor
I_1 = moment of inertia of cross section at small end of tube
I_x = moment of inertia of any cross section of column at distance x measured as shown in Fig 6(A) and
$I_x = I_1\ (x/d)^n$

the general equation for Euler columns of the types shown in Fig. 6 is

$$P = m\,E\,I_2/L^2$$

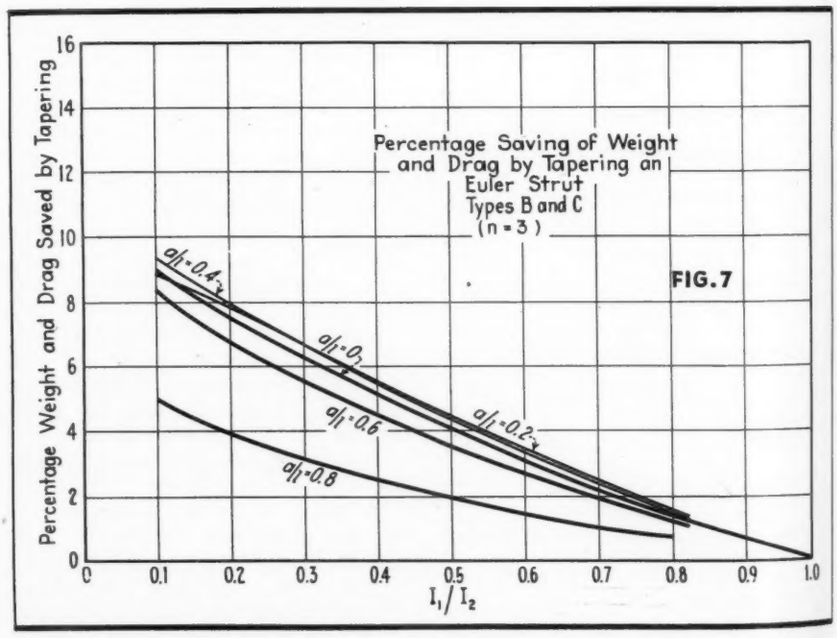


FIG. 7

Fig. 7—Percentage saved in weight and drag by tapering a Euler strut of constant thickness, type B streamlined and type C round, as shown in Fig. 6

Values for n and m are given in Timoshenko's "Theory of Elastic Stability," p. 128-139. For a column in the form of a plate of constant thickness and varying width the exponent n is equal to one, and for a solid truncated cone or pyramid n is equal to four. The values of n for tubes of the usual dimensions and types shown in Fig. 6 are: For type B, $n = 3$; type C, $n = 3$; and for type D, $n = 1$. For type B and C, n would equal four if the thickness varied uniformly.

The saving in weight for equal load carrying capacity for tubes of type B and C over straight tubes is shown in Fig. 7. The maximum saving of 9.5 per cent occurs when a/L equals 0.4 and I_1/I_2 is 0.10. For the round strut with taper in thickness only, type D, maximum saving in weight, shown in Fig. 8, is 14.5 per cent when a/L equals zero and I_1/I_2 equals 0.175. The reduction in drag for the tapered streamline is the same percentage as the reduction in weight for this strut.

Not all of the saving in weight is in the strut proper, however, because the fittings at the end contribute an appreciable part of the total weight. In a 60 in. × 2 in. × 0.05 in. aluminum alloy tube, for example, the end fittings may weigh one-fourth the tube weight. To reduce the end to 1 in. in diameter will result in roughly halving the fitting weight. Combining this effect with the reduction in tube weight will result in a saving of about one-fifth with no loss in strength.

Since it is possible to vary the taper over quite long lengths, the uniformly tapered tubes may be useful in truss designs where weight saving is important. Although, from a production standpoint it might sometimes be better to use a step-taper rather than straight-taper tube. The advantage in favor of the varying tapered tube over the step-tapered would depend somewhat on the difference in cost and weight. Certainly where the critical load is a tension one the step-tapered tubing would be most satisfactory.

Other designs besides those indicated above can take advantage of the possibilities in increasing or decreasing the thickness at the ends of the tapered tubes. An airplane landing gear strut of the type shown in Fig. 9, is an example of the use of combined taper in thickness and in O.D. in a member which carries bending and end loads while acting as a bearing at one end.

Other possible design advantages obtainable with tapered tubing are:

1. Possibility of securing clearances at certain points by reducing the diameters locally. This impairs the strength of the member but not the stiffness to any appreciable extent since the reduced length is small.

2. For members in machine structures which may have a natural frequency which coincides with some impressed frequency, the resulting vibration can be decreased or eliminated by increasing the O.D. and reducing the gage, so that the stiffness and frequency will be raised above the critical range with no increase in weight.

3. Thick ended tubes lend themselves to forging. The ends can be upset to make flanges as for a torque tube or a bolted joint. Upsetting the ends for internal or external threading is another possibility.

4. For many applications such as engine push-rods where weight saving is not so important as having a rod which will operate satisfactorily as a column and yet have sufficient material at the ends to take bearing and wear load.

5. Tubes with controlled diameters are suitable for frames and bents to resist bending moments set up by side load. Certain designs of landing gears of the type are of this nature since they must withstand side loads when landing.

Pleasing variations in line and contour are particularly important in the design of metal furniture, lighting equipment, supports for cabinets, household and industrial equipment, automotive, aircraft and bus parts. There are many other designs the utility of which can be improved, not so much from a strength as from a "convenience" and "appearance" standpoint. Included in the group are such items as socket-end tools, tripods, door handles and door pulls, nozzles, water tubes, parts for agricultural tools, musical instruments and many others.

[EDITOR'S NOTE: We are indebted to T. C. Bennett, Naval Aircraft Factory, for the technical aspects of this discussion. These are not, however, to be construed as official opinions of the U. S. Navy Department.]

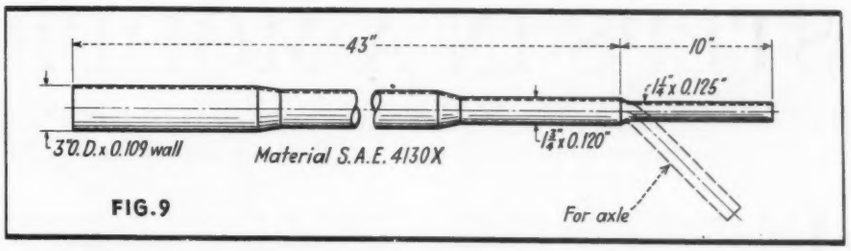


FIG. 9

Fig. 9—Step-tapered tube for airplane landing gear struts which must carry bending and end load. End of member provides bearing surface for the wheel. By tapering it is possible to get the desired small section for the axle without the problem of making additional joints; small end need only be bent to proper angle by forging

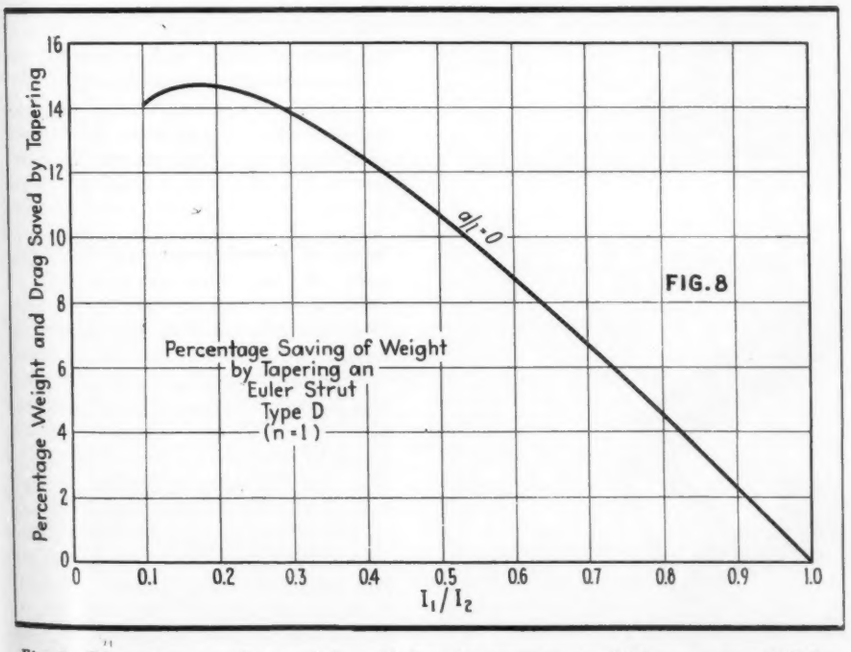


FIG. 8

Fig. 8—Percentage saved in weight and drag by tapering in thickness a round Euler strut, type D, as shown in Fig. 6

STEPS IN A MODERN DESIGN

JOHN C. FAGAN
Proctor Electric Company

IT is a far cry from the first pressing "irons" to the modern thermostatically controlled electric iron. Yet in the past few years the so-called "modern" irons have gone through successive redesigns to improve operation and control and to reduce weight—improvements which lessen fatigue, aid appearance and increase sales.

Original irons were probably heated stones or pointed pieces of metal, most likely bronze, with a thin metal handle insulated with cloth. For several hundred years there has been in China an interesting iron—a hollow brass casting pointed at both ends, having a metal lid hinged at one end and a clasp on the other, with a wood handle on top. Hot coals, placed in the hollow casting, furnish the heat.

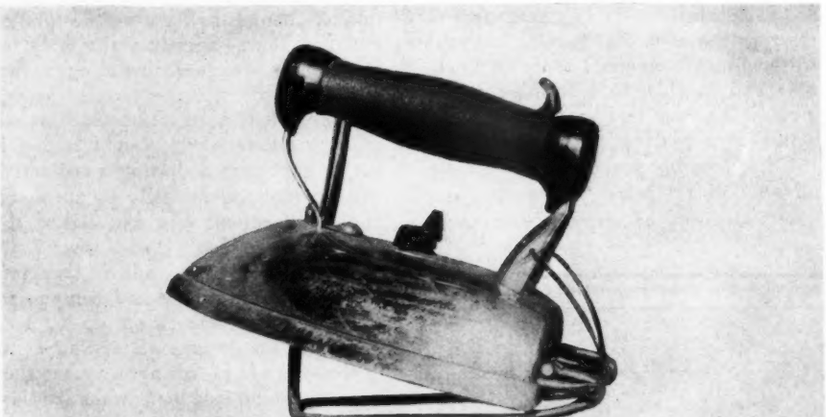
The first electric irons had many shortcomings. They were a dangerous fire hazard, not having a thermostat. The thermostat, or current shut-off device, which came into use in about 1925, was a definite step forward in safety, economy and convenience. A short time later the adjustable automatic iron appeared; a few years later the high-speed irons of 1,000 watts and lightweight irons were developed.

Our own experimental work led to the development of an automatic stand that allowed one to rest the iron without having to lift it onto a separate stand, and thus took nearly all of the weight lifting out of the ironing process.

Three models were developed, each in turn serving to point out definite drawbacks that could be eliminated by careful redesign. These various models are illustrated below together with brief comments on the design disadvantages encountered.

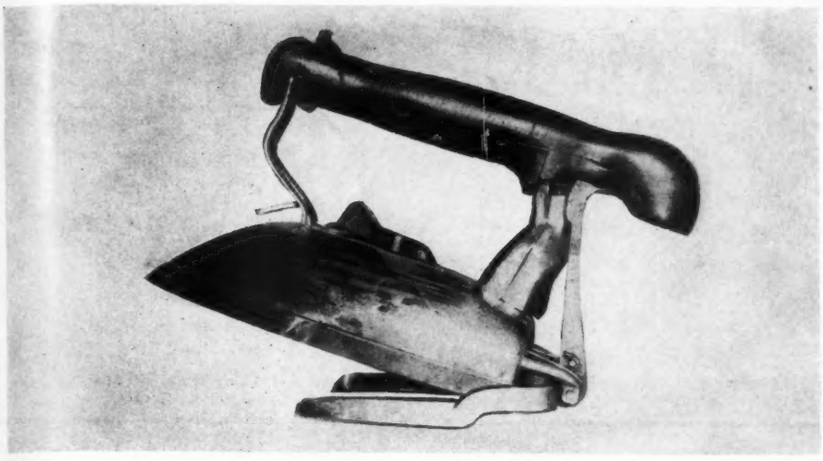
The third model proved a successful ironing device, except for appearance and a few minor drawbacks. Several users complained about the size of the handle, others said that the legs still had a tendency to catch. Some did not like the appearance of the exposed springs and others thought the appearance on a whole was displeasing. This was understandable as the models to date were made solely to demonstrate the usefulness of the idea with no thought given to appearance.

Before placing this third model on the market, it had to be restyled into a modern looking appliance, and the mechanism studied from design and production angles. It was decided to mold the handle of phenolic plastic in a streamlined, hand-fitting shape entirely inclosing all moving parts and springs to improve appearance.



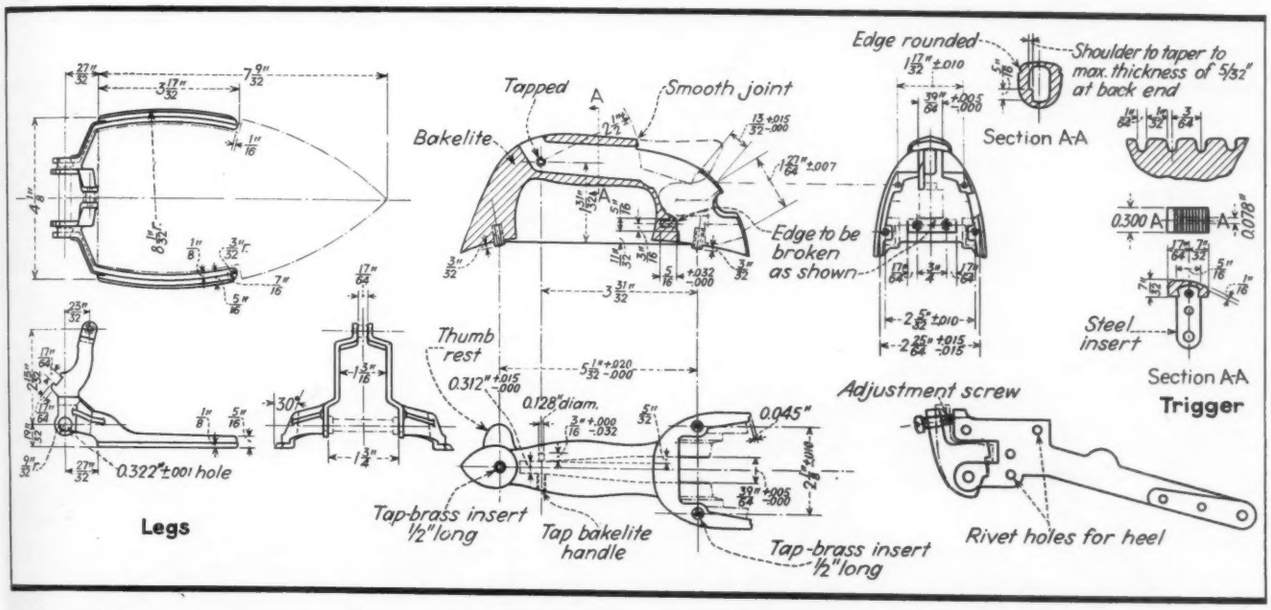
First model built along lines proposed by one of our inventors, Mr. W. H. Ginder, had a thin metal stand which was recessed in the flat bottom plate or sole plate. This stand raised the whole iron off the table surface when the pressure on the handle was released. Some definite drawbacks appeared immediately, the most serious being dragging of the metal stand on the fabric, even though the edge was smooth. Also quite a large area of the heating surface had to be cut away to accommodate the stand construction. The models illustrated were built-up out of stock parts solely for the purpose of design study. Each was tested under service conditions as a guide to design.

Second development lifted the support off the material and held it until released by a catch or trigger. This was accomplished by having the handle, which was hinged at the rear, raise in the front where a release catch was located. The handle acted as a simple lever that was connected to the stand by means of a link. This model also had a stand consisting of legs, hinged at the rear about an inch back of the sole plate, and straddling each side of the plate. Tests brought out the fact that with the hand in an unnatural position, considerable pressure was required to push down on the front of the handle in order to raise the legs off the surface of the material being ironed.

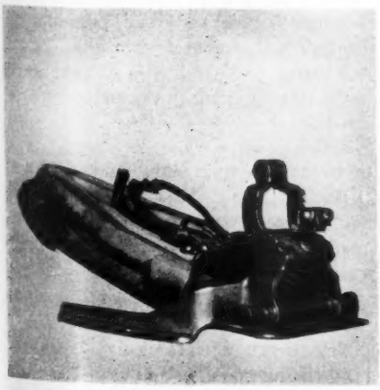


In the third model, the handle was hinged at the front so that the heel of the hand applied the leg-raising and latching pressure. A cam located at the rear of the handle bore against a roller fastened to an upright lever. This lever was an integral part of the axle splined to the two legs.

Difficulty arose in assembly in keeping the legs accurately spaced with respect to the cover. To overcome this, the cam part of the handle was redesigned. The lower section was hinged; and the upper section was adjustable by a small setscrew at the top. This arrangement allowed compensation for any wear which might occur in the lifting mechanism after several years' use.

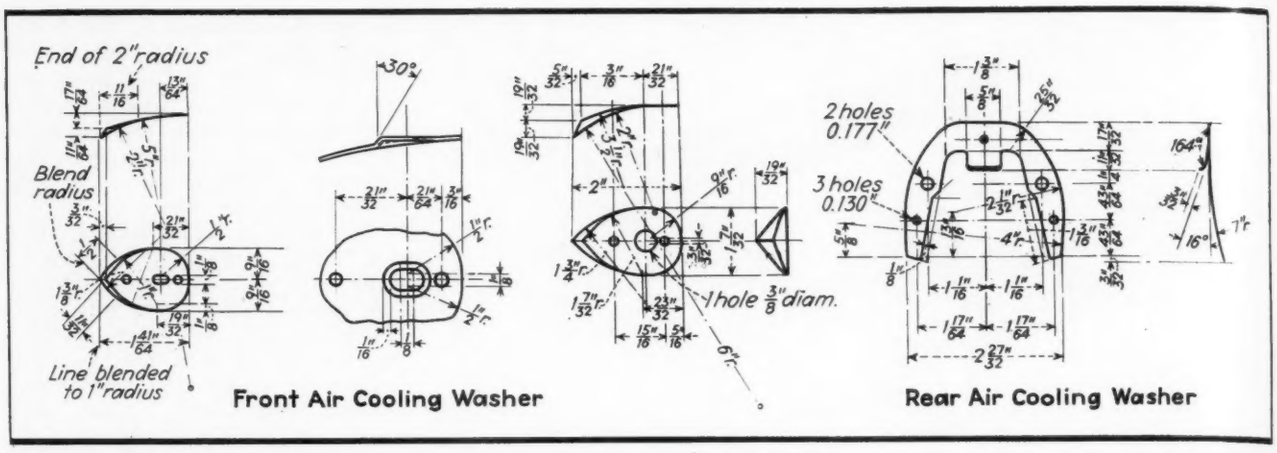


Die castings were proposed for the intricately shaped legs but the factor of strength and operating temperature of the parts ruled out this possibility. The final decision was to make the legs "L" shaped stampings, using the same blank for each part, but forming left and right. These pieces are stamped from ⅛ in. steel, formed over at right angles to form a foot or tread. A spacer is stud-riveted in the middle of the "L" and also at the top. The axle or bearing shaft, passing through the center of the lower spacer, has a 2½ in. bearing; this is the distance the legs are spaced at the bottom. The top spacer, ½ in. long, forms a bearing for a hardened steel roller. A hardened steel cam inside the hollow bakelite handle bears against this roller. The cam is a 4 in. steel beam pivoted at the front, having a smooth pad of plastic fastened to the back directly over the cam contour so that the pressure can be applied where it is needed. Only this pad moves up and down, instead of, as in two of the previous models, the entire handle.



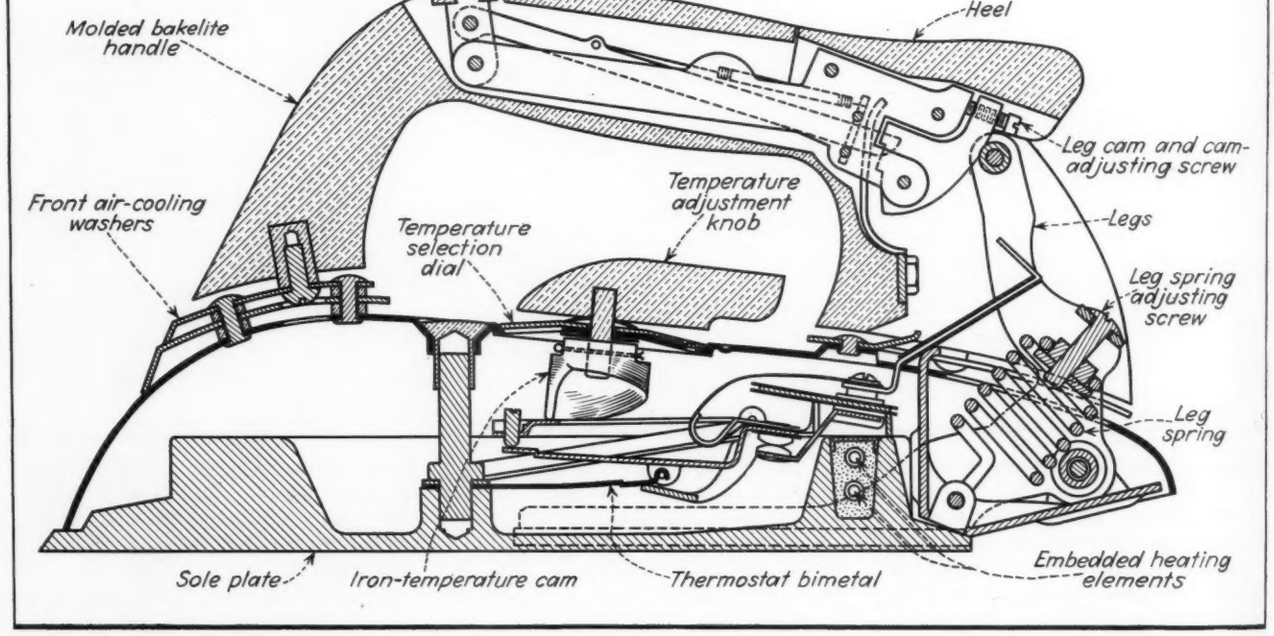
Upon spring strength depends the ability of the iron to raise itself. The lower end of the spring is fastened to the lower section of the sole plate. Half way up the "L" shaped legs is fastened a flat cross-bar through which passes a screw, by means of which spring tension is adjusted.

Much time was spent in developing this "main spring" as we call it, first, because it has a considerable job to do in lifting the iron, and secondly, because it has to work in a temperature of over 300 deg. F. Several kinds of special-alloy music wire were first tried, but when heated under strain they lost their characteristics. We next tried different alloys of stainless steels. Spring diameter was kept as large as possible with maximum number of turns to obtain the required tension. The spring material found best suited for the job was stainless steel of 8 per cent nickel and 18 per cent chrome, heat-treated at 750 deg. F. for 8 hours. Without heat-treatment the material is no better than music wire. The spring is one inch in outside diameter and contains 28 in. of 0.112 in. diameter wire. *(Continued on next page)*



Air-cooling fins, mounted between the cover and each end of the handle, reduce handle temperature from 20 to 40 degrees; they also add to the appearance of the iron.

These developments were incorporated in a fourth model, the final design. The sole plate was a new casting of a lighter design than previous models.



The "speed selecting" dial of fabrics is a 2 in. crowned plate under the adjusting knob, with fabric names etched into it. Movement of the pointer sets iron at the temperature desired. If the user is a fast worker, the adjusting knob can be forced hard to the right and the whole dial will rotate in the top of the cover about 20 angular degrees. The heat is thus pushed up approximately 40 degrees in temperature for each fabric. On the other hand, for slower workers, and a cooler iron, the knob is forced to the left and the range of the dial of fabrics is dropped 40 degrees. The dial can be set at high, low or medium as the user chooses. All of these adjustments are through a horizontal cam that rotates and raises or lowers a lever that works against the thermostatic strip.

AFTER THE HAND-MADE model was completed, it was put through an actual routine of strenuous ironing tests. Before the tools and dies were made, the iron was submitted to a commercial artist who added some details to the design to give it a little more eye appeal. Most notable of these were the red lines on the side of the handle and precision printing on the adjustable dial. A number of the first few irons were sent to an independent testing laboratory and given tests for safety, reliability and balance. The most strenuous of these tests, called "the abuse test," was made on a specially constructed machine which opened and shut the legs while the iron was set at its highest temperature and was held suspended in air. This was found to be much more severe on the lifting mechanism than if the iron were resting naturally on the ironing board. Irons ran successfully over 250,000 cycles during this series of tests, without any sign of failure in the latching or in the stand-lifting mechanism.

HYDRAULIC FLUIDS – I

Fundamentals Affecting Circuit Efficiency

NORMAN E. MILLER
Consulting Hydraulic Engineer

DURING the last ten years the field of industrial hydraulics has flourished under the stimulus of increased scientific and applied research, resulting in fluid power adaptations for literally thousands of industrial purposes.

Among the many new and interesting problems coincident to this development is the one of hydraulic fluids. Cooperative research between the manufacturers of hydraulic equipment and the refiners of petroleum has resulted in most gratifying progress. However, the broad diversification of present day hydraulic power applications usually necessitates individual study of the several variable and influencing factors before proper selection of the hydraulic fluid can be determined.

It is the purpose of this article to point out only those factors that are of fundamental significance to both the designer and the user of hydraulic equipment.

First, it might be well to state why the proper type of fluid is considered a first essential for satisfactory performance.

A. High pressures between moving parts in hydraulic systems are maintained in two ways: (1) by close ground and lapped clearances, and (2) by a viscous seal consisting solely of the oil film.

B. The overall efficiency attained in normal operation is usually quite critical to viscosity changes.

C. Because of the exacting precision standards of manufacture required for maintaining high working pressures, hydraulic equipment is necessarily of an expensive nature.

D. The longevity and economical maintenance of the equipment are largely dependent upon the use of the proper fluid medium, free from corrosive effects, possessing as high a viscosity index as is practical and including high resistance to abrasion and wear of moving parts.

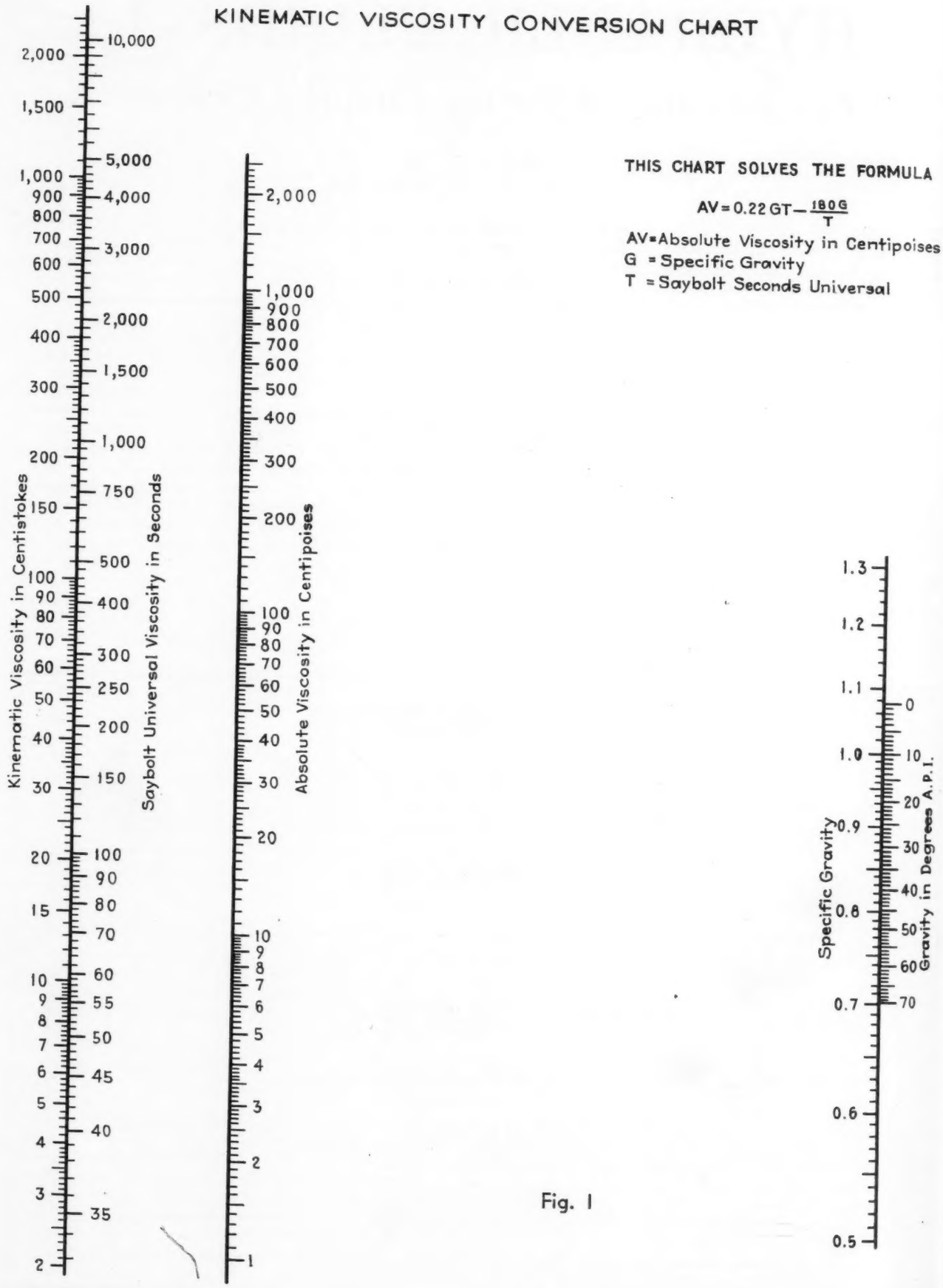
Among the more common basic functions of the hydraulic fluid is the requirement of transferring energy or work in a machine or other mechanical equipment. This is generally accomplished in a manner analogous to pure mechanical methods entailing the usual gears, chains, belts, and similar power transmission elements. Furthermore it must satisfactorily perform the requirements for adequate lubrication of the finely fitted moving parts in the circuit. Some of these parts, such as the line contact between the two gears of a gear pump or the leading vane edge against the cam ring of a vane pump. result in abnormally high unit pres-

TROUBLE SHOOTERS CHART
OIL HYDRAULIC CIRCUITS

MACHINE OPERATING CHARACTERISTICS	OIL CHARACTERISTICS	REMEDY
Slows down as temperature rises	Oil too light and/or viscosity index too low	Use heavier oil and/or higher index oil to reduce leakage in pump, motor, cylinder, etc.
Erratic action foaming or aeration of oil	Poor demulsibility, high surface tension of oil – Oil has absorbed moisture	Use oil with 1620 demulsibility or A.S.T.M. steam emulsion of 100 seconds max.
Sluggish	Oil viscosity too high	Use correct viscosity as specified by manufacturer. When sluggish at lower temperatures, especially on starting, use high index and low pour point oils
Corrosion of hydraulic system parts	Too high in acidity, oil may be compounded of harmful ingredients	Specify acid free mineral oil, neutralization number of 0.10 max. for combined acidity, saponifiables less than 1 per cent
Sticking valves (hydraulic)	High oxidation; oil not properly refined	Check operating temperature. Do not exceed 140 deg. F.-160 deg. F. for best results. If temperature is satisfactory change to stable high index oil
Excessive leakage	Oil too light and/or viscosity index too low also loose connections or excessive clearances	Tighten all connections and check clearances. If leakage is still excessive use heavier and/or higher index oil
Pump noisy	Probably cavitation; oil viscosity too high causing excessive pressure drop in intake line or intake line too small creating excessive oil velocities	Use higher index and/or lighter oil. Use oil of lower pour point. Check pump intake size and install larger line if necessary

This chart is intended primarily to assist the engineer or technician in analyzing defects in the circuit due to the fluid medium

KINEMATIC VISCOSITY CONVERSION CHART



THIS CHART SOLVES THE FORMULA

$$AV = 0.22\,GT - \frac{180\,G}{T}$$

AV = Absolute Viscosity in Centipoises
G = Specific Gravity
T = Saybolt Seconds Universal

Fig. 1

sures which may far exceed the actual operating pressure of the system. In such instances, obviously wear resistance is highly desirable as measured by the ability of the fluid to maintain a good seal and yet resist abrasion between the moving parts. This point will be covered more fully further on.

Collective experience gathered from the field and from laboratory tests over a period of years indicates certain physical and chemical properties of the fluid to be most important. These characteristics in their general order of importance are:

1. Viscosity
2. Wear Resistance
3. Demulsibility
4. Viscosity Index
5. Pour Point
6. Neutralization Number
7. Stability
8. Miscellaneous Properties

There are many applications where the relative order of importance as arranged in this list could well be changed. The arrangement shown is, however, desirable from the standpoint of average requirements.

The equipment and design engineer in evaluating the effect of each specification, should take into consideration the anticipated pressure range, ambient and reservoir temperatures, pitch line velocities, piston and valve plate rubbing speed, cycling sequences and other highly influential factors characteristic of the circuit in question. For immediate purposes it would perhaps be well to discuss briefly the more important specifications in their general order of importance and engineering interest.

Viscosity

For any given hydraulic system there exists an optimum viscosity for attaining the maximum overall operating efficiency. A viscosity lower than the ideal will permit leakage, reduce the volumetric efficiency of the pumping unit and, ultimately, lower the overall efficiency of the complete circuit. This loss of efficiency is more pronounced where wide ranges of operating temperatures are encountered. Oils that are of higher viscosity than the ideal impose an additional load because of greater flow resistance, which will also lower the overall efficiency. Added load results from the greater shear resistance of the oil film of excessive thickness and viscosity as reflected by the increased pressure drop through the system. Inasmuch as the usual mineral oil changes viscosity considerably under changing temperatures, the oil selected must have the correct viscosity at the temperature at which the system will operate the greater part of the time.

Generally speaking, oils having a viscosity of 150 to 300 SSU (Saybolt Seconds Universal) at 100 deg. F. are in the desired range for normal service. Where extremes of pressure and temperature are encountered, oils having viscosities varying from 200 SSU to 1000 SSU at 100 deg. F. are sometimes employed. Where low temperatures are encountered, such as installations subjected to winter weather, oils having a Saybolt viscosity of 100 and even as low as 50 sec. at 100 deg. F. are used. However, one must not lose sight of the fact that all of these oils if properly applied will have approximately the same viscosity at the normal operating temperature of the system. The foregoing factors plus other special conditions make the viscosity specifications of paramount importance.

Viscosity has long been defined in terms of Saybolt Seconds Universal, abbreviated SSU. This method for determining viscosity is essentially a matter of accurately timing a given flow through an orifice of fixed dimensions. This method, however, has inherent weaknesses that introduce errors under certain conditions. Because this fact is now generally recognized, a more scientific method is now coming into wide use. This new method determines the kinematic viscosity and utilizes a suspended level capillary tube immersed in a controlled temperature liquid bath.

Kinematic viscosities are observed directly by the operator. The nomograph chart shown in Fig. 1 will conveniently perform conversions from Saybolt to absolute or kinematic viscosity.

As indicated on the nomograph chart

AV = Absolute viscosity in Centipoises

G = Specific gravity

T = Time in Saybolt Seconds Universal

The nomograph is based on the equation

$$AV = 0.22GT - (180\ G/T)$$

Because of the current trend to utilization of absolute values in measuring viscosity a kinematic viscosity scale will be included on the Dean and Davis Viscosity Index Chart which will appear in Part II of this article.

Viscosity decreases inversely with temperature rise, at a modified logarithmic rate. Because of this factor, even

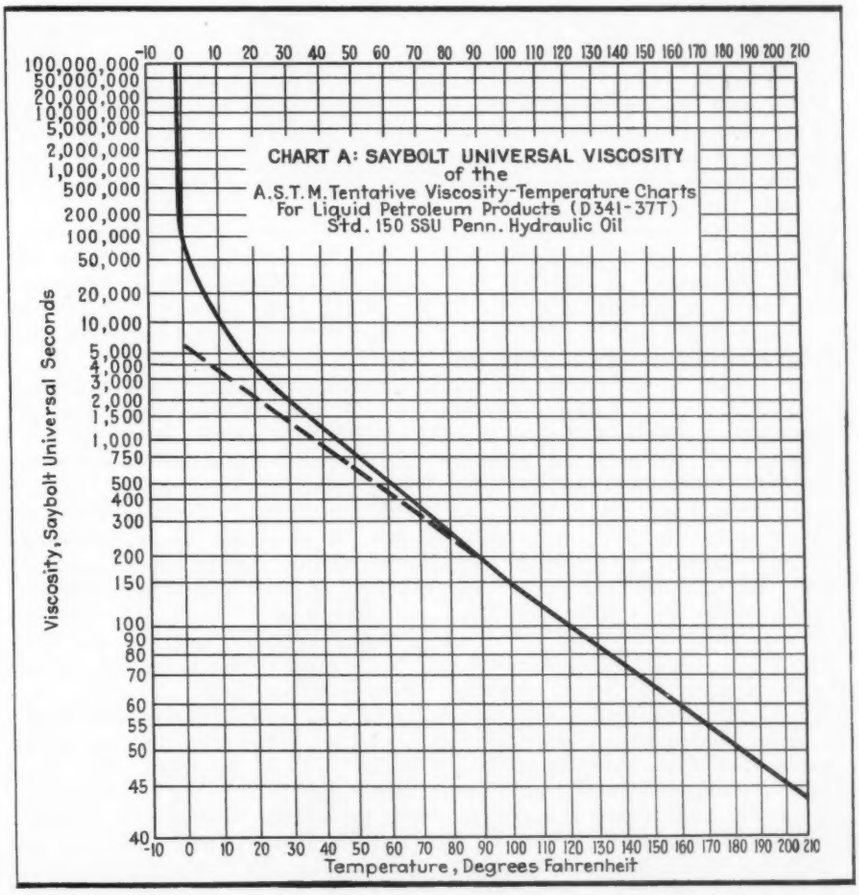


Fig. 2—Viscosity-temperature chart for Std. 150 SSU Penn. hydraulic oil

small temperature changes in the lower temperature scale cause amazingly great increases in viscosity. In this connection it might be well to point out that so-called viscosity curves are commonly plotted as a straight line function on charts similar to that shown in Fig. 2. However, in the temperature range around zero degrees Fahrenheit and for a considerable range on either side of zero, ordinary mineral oils do not follow this straight line viscosity curve. This truth was established in several instances by cooperative research between industry and the large refiners.

During these investigations it was found that instead of the viscosity curve remaining a straight line function, there existed a tendency for the curve to rise rapidly in viscosity values in the lower temperature range. A typical example is shown in Fig. 2, which is a viscosity-temperature chart for a typical paraffin base hydraulic oil with actual observed values plotted for the lower temperature range. The amount that the viscosity curve will deviate from a straight line was found to be largely dependent upon two factors, namely, base or origin of the crude stock and pour point, the latter of which is commonly lowered by the addition of compounds purposely added to produce a decrease in pour point value. Other phases of low temperature characteristics are covered later, under the heading of pour point.

In general, the equipment manufacturers' recommendations as to viscosity are based on wide experience plus the findings of extensive experimental and research projects. The equipment user will therefore, except in some special installations, benefit by closely following the equipment manufacturer's viscosity recommendations.

Wear Resistance—Film Strength

In considering the various requirements for a satisfactory hydraulic fluid the matter of wear resistance assumes a special significance. As was previously mentioned, unit pressures at different points in the circuit quite frequently exceed by a considerable margin the so-called operating pressures. The need for resistance to film rupture is therefore obvious.

There have been many attempts to develop a successful wear resistant agent. Certain compounded oils contain active sulphur and/or chlorine or a combination of the two. Animal fats or other saponifiable materials may also be present because of their known ability to increase film strength.

With this intended increase in wear resistance one might expect reduced abrasion and wear, but frequently high pressures and high reservoir, or even high localized temperatures, cause a chemical reaction of the additive agent, forming injurious corrosive compounds. The resulting corrosion causes rapid deterioration of the hydraulic equipment. Thus the high film strength has defeated its originally intended purpose. Consequently, it should be remembered that although an oil possesses initially high film strength it may not be good in terms of wear resistance, but on the contrary may, through possessing corrosive constituents, be actually harmful.

Difficulties of this nature have been a source of discouragement in the past to the users of expensive hydraulic equipment. Because resistance to wear is extremely important, there has been considerable activity by several independent research organizations to find a workable solution. Here again, cooperative research between the refiner and equipment manufacturer has culminated in most encouraging results. Recent research concerning wear resistant additives has resulted in almost inconceivable reductions in wear and deterioration.

Although not yet produced in large quantities, hydraulic fluids incorporating the use of wear resistant additives, such as chlorinated aromatic compounds, will be relatively inexpensive and should contribute welcome benefits in reduced operation and maintenance cost to hydraulic equipment users throughout industry.

Demulsibility

Among the interesting facts established by experience, relating to the successful operation of hydraulic equipment at high operating speeds and pressures, is the importance of demulsibility in hydraulic fluids.

Aeration, foaming, loss of film strength, tool chatter, tool breakage and other ills which occasionally perplex users of hydraulic controls have been definitely linked to the poor demulsibility characteristics of the fluid used. It has been found that poor demulsibility characteristics facilitate air and moisture absorption in the hydraulic circuit.

Effects of air are readily discernible, for it usually results in chattering, noisy operation, erratic action and generally poor control. Effects of moisture are not so easily detected but are likely to be just as damaging. This becomes apparent when it is considered that the addition of quantities of water to the hydraulic fluid in amounts as low as two-tenths of one per cent will materially reduce the film strength. Hence, water or moisture even in small quantities in the hydraulic circuit is to be guarded against zealously. The most common cause of moisture being present in the circuit is condensation that occurs in the oil reservoir during temperature fluctuations in the surrounding atmosphere and in the circuit itself. Introduction of moisture into the circuit is augmented by high ambient humidity. Once this moisture is entrapped in the fluid it helps form an emulsion resulting in lowered film strength, increased tendency to foam and finally, increased acidity.

To overcome demulsibility ills, recent developments in the chemical industry have resulted in synthetic resins that, while relatively new, have been used in certain applications to great advantage as hydraulic fluids. These compounds are claimed to have the advantage of perfect insolubility with water. This perfect resistance to water absorption is attributed among other things to the extremely high specific gravity. The new compounds have a gravity of approximately 1.45 in contrast to the 0.85 specific gravity of ordinary hydraulic fluids. A particular advantage is found in their extremely high flash and fire points for use in circuits constructed adjacent to high temperatures such as injection molding machines.

Aside from the hydraulic fluid itself there are also preventive methods that can be used in constructing circuits that will largely eliminate the entrapment of air and moisture in the circuit.

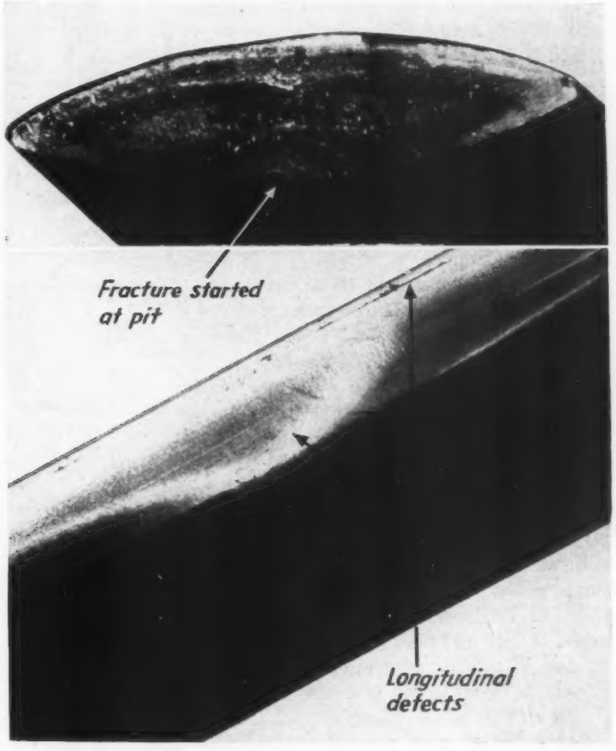
Since the inclusion of air and moisture in the operating system is directly contrary to optimum results, the demulsibility specification is of special importance. The two methods used to evaluate demulsibility are commonly known as Herschel demulsibility number, and A.S.T.M. steam emulsion number. The Herschel number should run 1,620 minimum and should maintain approximately this value after a hundred hours or more of usage. Where the A.S.T.M. steam emulsion number is a means of evaluating demulsibility, the fluid should have a steam emulsion number of approximately 100 seconds maximum, for complete separation. Oils with extremely high resistance to moisture absorption will sometimes show a steam emulsion number as low as 30 seconds for complete separation. The lower the steam emulsion number the higher the resistance to moisture absorption and the more desirable for hydraulic use.

[*Editor's Note:* The other important characteristics of hydraulic fluids will be covered in Part II of this article, to appear in the October number.

CAUSES AND CURES

PRODUCT ENGINEERING will pay $3 for each example published in Causes and Cures. Where illustrations are necessary, include drawings, rough sketches or photographs

Improper quenching technique is a common cause of intercrystalline corrosion exemplified in this 24ST aluminum part. All wrought aluminum alloys of the duralumin type are susceptible to intercrystalline corrosion under certain conditions. Characteristic of this type of corrosion is that only a little corrosion product is visible on the surface of the alloy. Proper solution heat-treatment calls for careful temperature control and rapid cooling. Specifications should demand that best combination of corrosion resistance and tensile strength be obtained by quenching in a large volume of cold water immediately after solution heat-treatment. Small parts must be *emptied* from container into cold water.



Surface defect, such as checks, pits, inclusions, grinding or tool marks as are shown at the bottom, was the starting point of the fatigue fracture shown at the top. Specifications must include allowance for sufficient grinding to remove surface defects. Tool damage can only be eliminated by proper care. Close inspection will usually prevent such failures.

Food-mixer motors, low-cost commutator type, created severe radio interference, customers complained. The manufacturer corrected this serious objection by connecting very small and inexpensive condensers across the line.

Tinning spun phosphor-bronze cream separator plates by hot dipping resulted in a coating which was stained yellow and was gritty by adherence of dross. Also, the phosphor-bronze, originally hardened by the spinning operation, had lost its temper and softened. Investigation disclosed that both the dipping time was too long and the tinning bath too hot. A clean coating without softening the blades was obtained by dipping in a bath at 490 deg. F. until parts reached bath temperature.

Vibration problems are conceded to be the universal headache of the chief engineer. One package machinery designer found the answer in magnesium alloy as a material to be used in high speed reciprocating part; much less inertia resulted than with the steel part it replaced. Another engineer found that the inertia of an aluminum pusher when changing direction around a sprocket imparted considerable vibration to the mechanism. So he substituted machined plastic.

Lacquer finished dental stands got blue or brown streaks on them. The streaks took a long time to develop except when the surface was exposed to direct sunlight which accelerated the action. It was noticed that the streaks followed the lines of the hose, suspended in loops, used for water or air. It took a lot of pondering and testing before it was discovered that the anti-oxident used in the rubber compounding caused the trouble. Trouble was eliminated by changing anti-oxident.

HYDRAULIC CIRCUITS

Fig. 11—This circuit for bending bicycle frames shows automatic control of an extensive series of operations.

1. Cycle is started by opening three-way pilot operating valve *J*, which causes cylinder 1 to clamp work.

2. Toward the end of the stroke of cylinder 1 valve *I* is contacted by cam, and valve *B* is shifted, causing cylinders 2 and 3 to bend work.

3. When these cylinders have performed, pressure is built up, opening valve *G*, shifting valve *C*, causing cylinders 4 and 5 to make bends.

4. Valve *H* will then open, shifting valve *B*, returning cylinders 2 and 3. Oil is admitted to valve *C*, which causes cylinders 4 and 5 to return.

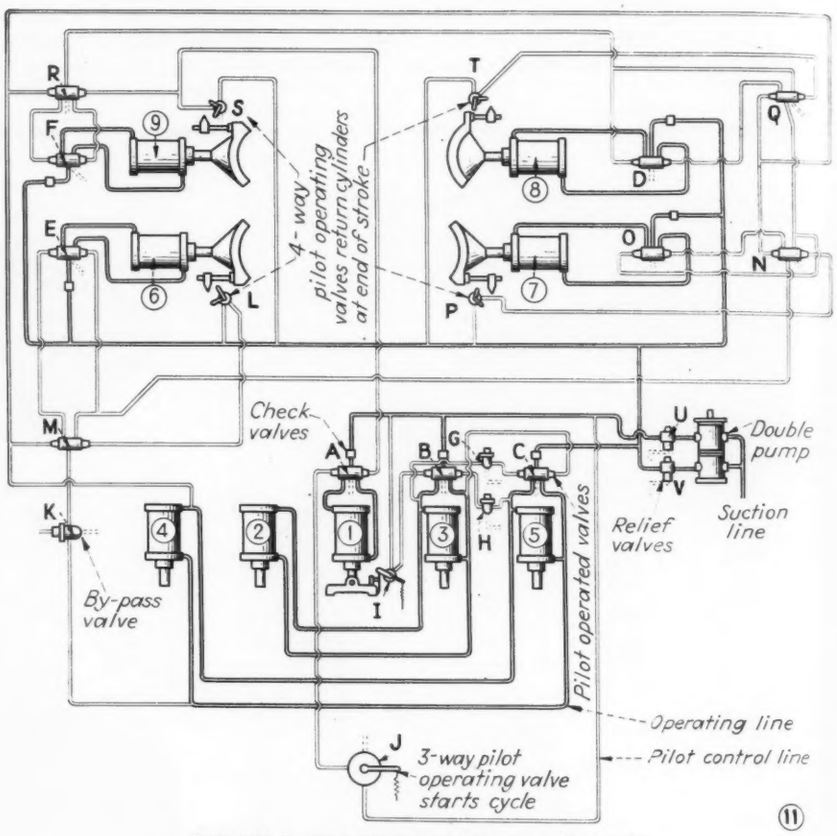
5. Upon the return of these two cylinders, built-up pressure opens valve *K*, which admits oil to valve *M*. This supplies oil to valve *E*, advancing cylinder 6. At end of stroke, pilot operating valve *L* and valve *M* shift. This reverses valve *E* and returns cylinder 6.

6. Oil flows also from valve *M* through valve *N* to valve *O*, which advances cylinder 7. At end of stroke, pilot operating valve *P* is contacted, shifting valves *N* and *O*, returning cylinder 7.

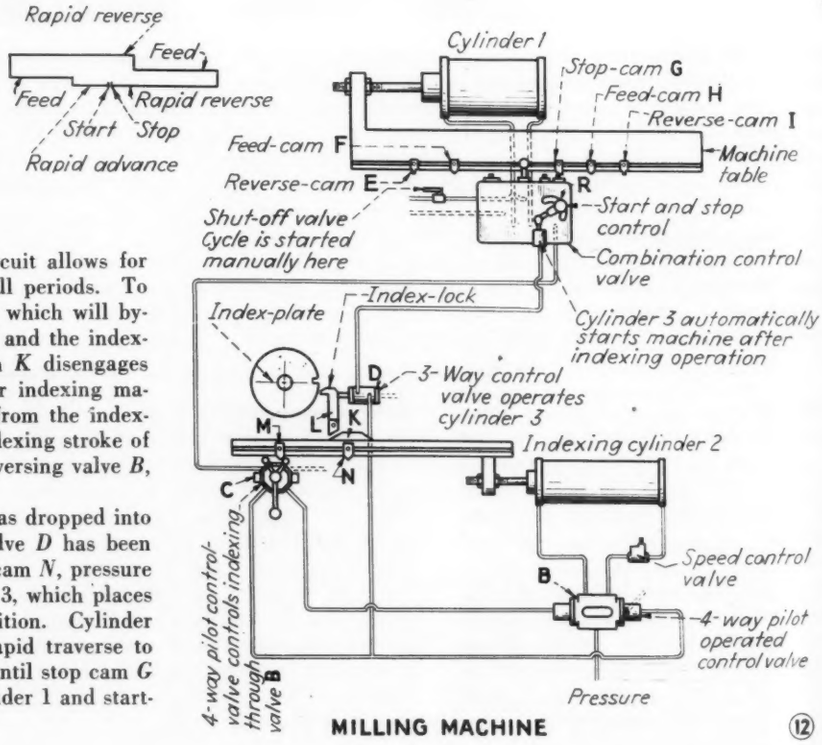
7. Oil will flow through valve *Q* to valve *D* and cylinder 8 will advance. At end of stroke, pilot operating valve *T* will be contacted, reversing valves *Q* and *D*, returning cylinder 8.

8. Oil flows also through valve *R* to valve *F*, advancing cylinder 9. At the end of stroke, pilot operating valve *S* will be contacted, shifting valves *R* and *F*, and cylinder 9 is returned.

9. Oil flows to valve *A*, releasing clamping cylinder 1.



BICYCLE FRAME BENDING MACHINE



MILLING MACHINE

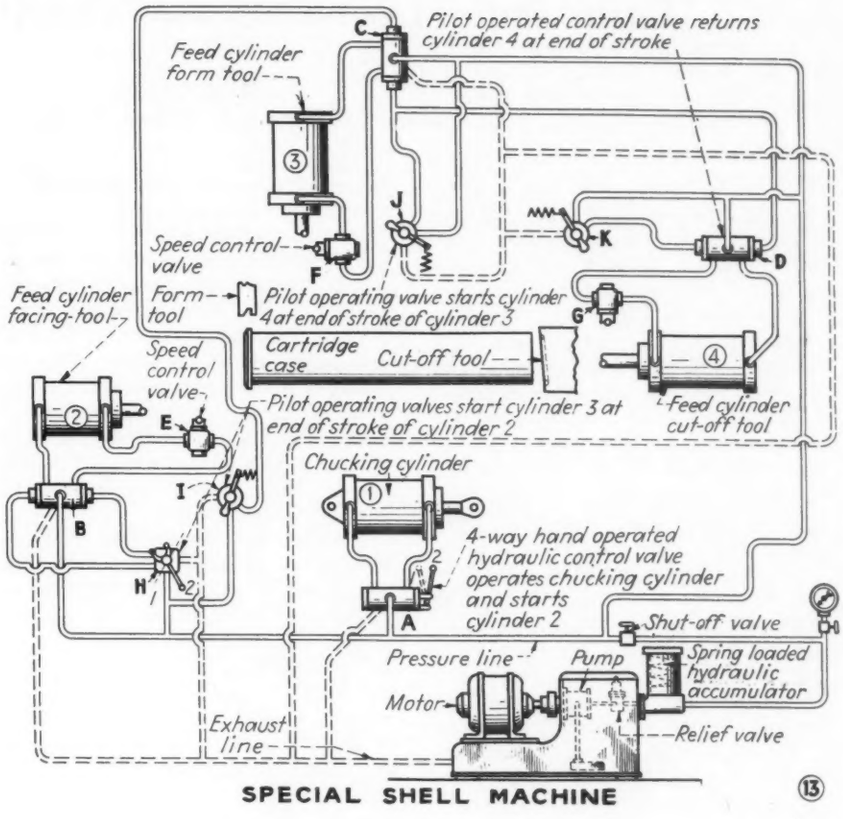
Fig. 12—Complicated milling machine circuit allows for difficult cycle of operations including dwell periods. To start the machine, open the shut-off valve, which will bypass oil to pilot valve *C*, shifting valve *B*, and the indexing cylinder will travel to the left. Cam *K* disengages indexing lock *L*, then engages ratchet for indexing machine table. When the lock is removed from the indexing plate, valve *D* is closed. At end of indexing stroke of cylinder 2, cam *N* will operate valve *C*, reversing valve *B*, and cylinder 2.

At the end of indexing stroke, latch *L* has dropped into the lock groove in the indexing plate, valve *D* has been opened, and when valve *C* was shifted by cam *N*, pressure was admitted through valve *D* to cylinder 3, which places control lever on valve *A* in the start position. Cylinder 1 will rapid traverse to the left, feed, rapid traverse to the right, feed, rapid traverse to the left, until stop cam *G* again engages stop plunger, stopping cylinder 1 and starting indexing cycle.

Pilot-Valve and Mechanical Control

J. C. COTNER
Logansport Machine, Incorporated

Fig. 13—Hydraulic operation of this special forming machine is set in motion by a four-way hand-operated valve which actuates chucking cylinder, and operates valve *B*, causing facing tool feed cylinder 2 to rapid advance until cam contacts speed control valve *E*. Cylinder then feeds for facing operation. When facing is completed, cams shift pilot valves *H* and *I*, operating control valves *B* and *C*; cylinder 2 returns rapidly and cylinder 3 advances. When forming operation is completed. cam shifts pilot operating valve *J*, operating valves *C* and *D*. Cylinder 3 then rapidly returns to starting position and cylinder 4 is placed into cut-off operation. At the finish of cut-off, cam shifts pilot operating valve *K*, operating control valve *D*. Cylinder 4 rapidly returns to starting position. Operator then places valve handle of control valve *A* into position 2 which releases work in collect chuck. Cam-operated speed control valves control the feed by metering exhaust oil from the cylinder.


Pilot operated control valve returns cylinder 4 at end of stroke
Feed cylinder form tool
Speed control valve
Feed cylinder facing-tool
Form tool
Pilot operating valve starts cylinder 4 at end of stroke of cylinder 3
Cartridge case
Cut-off tool
Speed control valve
Pilot operating valves start cylinder 3 at end of stroke of cylinder 2
Feed cylinder cut-off tool
Chucking cylinder
4-way hand operated hydraulic control valve operates chucking cylinder and starts cylinder 2
Shut-off valve
Pressure line
Pump
Spring loaded hydraulic accumulator
Motor
Relief valve
Exhaust line
SPECIAL SHELL MACHINE
13

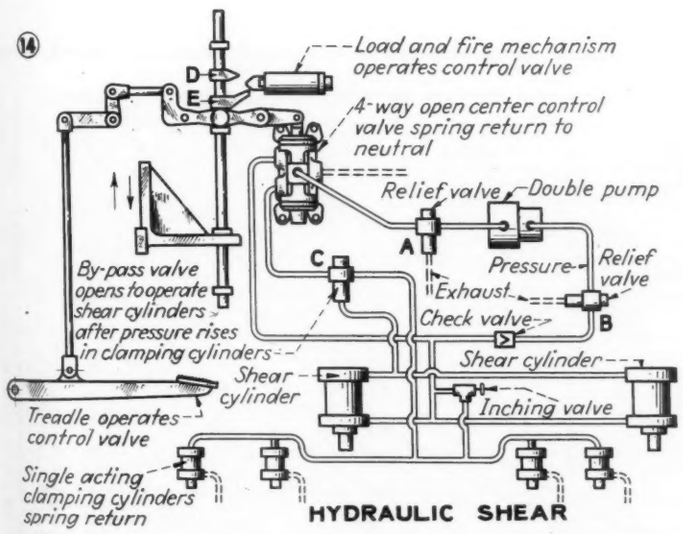


Fig. 14—Foot treadle and load and fire mechanism operate a four-way valve which controls a shear. Double pump is used to supply hydraulic power, the smaller having a low delivery to keep shearing cylinders up and off work during loading or standby period. In the working position oil is applied first to clamping cylinders and when predetermined pressure has been reached, by-pass valve will open and operate shear cylinders. Inching of shear can be obtained without operating treadle by bleeding off pressure from small pump through inching valve.

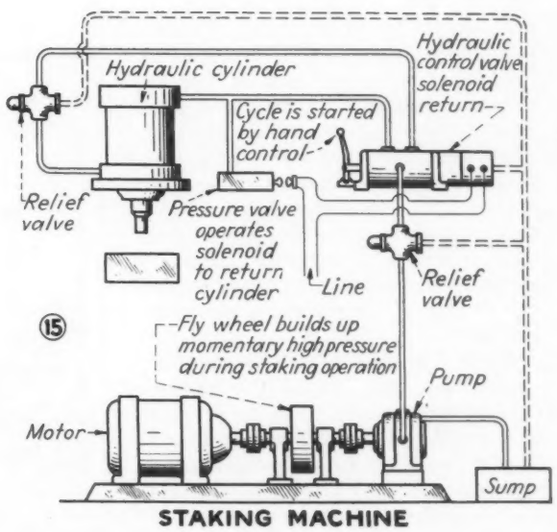


Fig. 15—Flywheel in assembly provides energy for momentary high pressure needed for staking operations with a small motor. Cycle is started by hand control. When pressure in ram reaches desired point, pressure switch closes circuit of solenoid which reverses control valve causing cylinder to return. Relief valve on return line is set at pressure just sufficient for ram return. During standby period, oil from pump flows through valve at reduced pressure eliminating heating.

RESISTANCE HEATING UNITS

Their Selection and Application — Part II

M. M. GREER

Industrial Sales Manager, Edwin L. Wiegand Company

IN the first part of this article (Aug. P.E., pages 351-53) the different types and forms of electric resistance heating units were described and some of the factors bearing on the selection of units were discussed. This concluding part of the article deals with ratings and life of heating units, and specifications relating to installation.

Determination of a safe rating for the type of unit chosen is perhaps the most important single factor in the successful application of electric heat. Even in those applications where long life is secondary to speed or convenience, it is important to know just how far one may go before life becomes non-existent. In the case of the incandescent lamp—itself a resistance heating unit—it is possible, with the knowledge that operating conditions are more or less established, to design a product with an approximate operating life in view. Not so with the average heating unit. The operating conditions and uses to which the unit may be subjected are so varied that an accurate prediction of the life in terms of hours, is virtually out of the question.

It therefore becomes necessary to fix certain standards of ratings and temperature requirements which years of experience and exhaustive tests have proved to be most conducive to reasonable life. Constructional details of the unit must always be a factor in setting these standards of safe rating, and for specific applications the manufacturer's catalog will prove to be an excellent guide.

Aside from the actual construction of the unit, the life of the heating element will, in general, be the product of a number of factors, including watt density (watts per square inch of active heated area), sheath temperature, and the frequency of the on-off cycle. An excess of any one factor will shorten the life but by compensation of the other factors, life may be kept normal. For example, if rapid cycling is occasioned by a too sensitive thermostat, lower watt density will compensate.

Watt density and sheath temperature are important as they affect the internal temperature of the unit. The resistor is the very heart of any heating unit and beyond certain limits deterioration of the resistor increases rapidly with increased temperature. It may be said that anything that tends to increase the internal temperature also tends to shorten the unit life. Conversely, if the internal temperature is kept at the most reasonable value consistent with the demands of economy and those of the application, the most reasonable life may be expected. Indeed, this one thought might serve as a guide throughout the whole process of selecting and applying heating units.

The internal temperature may be thought of as being the sum of the sheath temperature and the temperature gradient or drop between the resistor and the sheath. The sheath temperature will depend upon the manner in which the unit is applied and upon watt density. Curves are usually available in manufacturers' catalogs for estimating sheath temperature for each general class of application, such as air heating, oven heating, contact heating, and others. Fig. 4 shows a typical curve for determining sheath temperature of strip heaters operated in free or forced air. Similar curves are available for other types of application. Figs. 5 and 6 are for sheath temperatures for units in high-temperature ovens and units clamped to tank or other metal surface, respectively. The temperature gradient within the unit will depend upon the watt density and upon the effectiveness of the insulation in transmitting the heat generated in the resistor. In this connection the importance of a tightly pressed or solid insulation of high thermal conductivity will be readily apparent. The temperature drop through a hard, solid refractory may be several hundred degrees less than that through a similar heater having loose grain insulation. Consequently, the former heater will operate with a greater factor of safety at a given rating, or may safely carry a higher rating, so that fewer units will be required.

The more important that life and dependability become in relation to

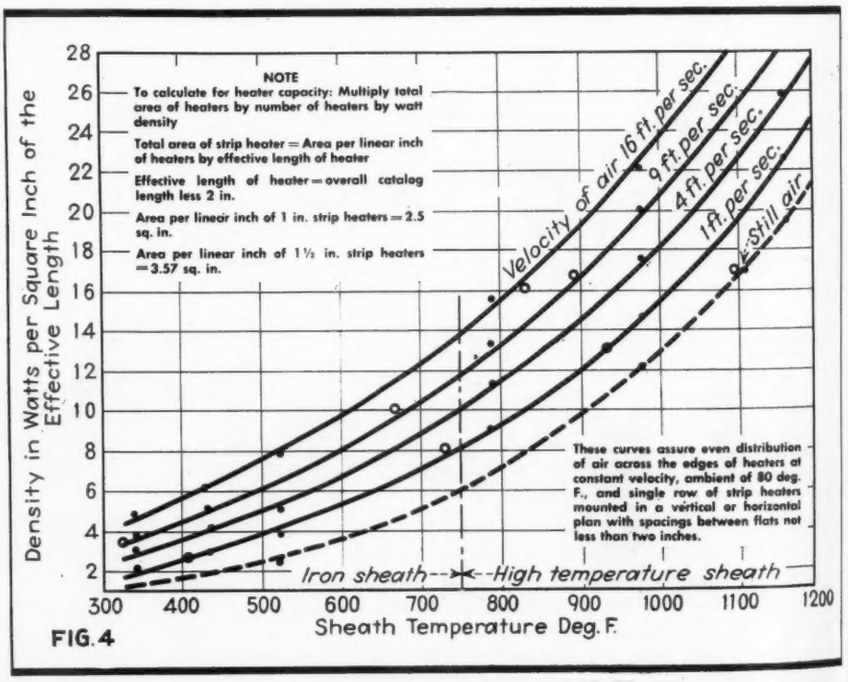

NOTE
To calculate for heater capacity: Multiply total area of heaters by number of heaters by watt density
Total area of strip heater = Area per linear inch of heaters by effective length of heater
Effective length of heater = overall catalog length less 2 in.
Area per linear inch of 1 in. strip heaters = 2.5 sq. in.
Area per linear inch of 1½ in. strip heaters = 3.57 sq. in.
Velocity of air 16 ft. per sec.
9 ft. per sec.
4 ft. per sec.
1 ft. per sec.
Still air
These curves assure even distribution of air across the edges of heaters at constant velocity, ambient of 80 deg. F., and single row of strip heaters mounted in a vertical or horizontal plan with spacings between flats not less than two inches.
Iron sheath
High temperature sheath
Density in Watts per Square Inch of the Effective Length
Sheath Temperature Deg. F.
28
26
24
22
20
18
16
14
12
10
8
6
4
2
300
400
500
600
700
800
900
1000
1100
1200
FIG. 4

Fig. 4—Curves of sheath temperature at various watts density of Chromalox strip heaters in free air and in forced circulation of air

other considerations, and the more uncertain it is that heat will be readily carried away from the unit and that operating temperatures will be limited, the greater will be the desirability toward a conservative heater rating. Table III, listing allowable watt densities for immersion heaters in various liquids, will serve to illustrate.

Water will absorb heat very rapidly and the sheath temperature of a water immersion heater can never exceed by more than a few degrees the boiling point of water. Such heaters for occasional or intermittent use, percolators for example, may have high ratings for quick heating. Where dependability is an important factor or heaters are in continuous use, as in industrial applications and domestic water tanks, lower ratings are advisable.

Oil may reach higher temperatures than water and absorb heat less rapidly, therefore lower ratings are in order. Lead and molten salts reach much higher temperatures than oil, but absorb heat readily and heater ratings may be only slightly lower than those for oil.

And so on down the scale, to such materials as tar, asphalt, molasses, and glue which are very viscous, resist rapid transfer of heat from the unit and tend to carbonize or caramelize on the sheath of the heater if rated too highly. Glue is so liable to injury if overheated that it is rarely heated directly but rather through a water jacket surrounding the immersion heater.

Table III — Allowable Watt Densities for Immersion Heaters in Various Liquids

Material	Approx. Temp. In Deg F.	Watts Per Sq. In.
Water—occasional or intermittent service	212 Max.	40 to 60
Water—continuous	212	28 to 35
Oil—circulating	100–400	20 to 25
Oil—non-circulating	100–400	16 to 20
Lead	650–800	14 to 16
Molten Salts	600–950	10 to 15
Asphalt—Tar	200–600	6 to 8
Molasses	120	4
Glue	150	Unwise to heat directly; use water bath.

Having settled upon the type of unit and a rating in keeping with its intended service, the physical size and number of heaters necessary to make up the desired heater capacity may now be determined. It will often be found that modifications of some of the details, as originally planned, may be desirable from the standpoint of economy or may be made necessary because of physical limitations.

The surface temperature of the unit and the possibility of corrosion from contact with the material being heated will govern the choice of heater sheath. For contact heating where the surface temperature will not exceed 750 deg. F., heating units are usually furnished with steel sheath and with the less expensive nickel-chromium-iron alloy resistors. For temperatures between 750 and 1,200 deg. F. the sheath may be of chrome-steel alloy, stainless steel or Monel, and the resistor made of heat-resisting nickel-chromium alloy. In humid atmospheres, Monel metal sheath may be used.

Immersion heaters are supplied standard with copper or brass sheath for water heating and with steel sheath for use in oil and many alkaline solutions. For heating acids and other corrosive agents, heaters are available with sheaths of lead, stainless steel, Monel, Everdur, or other special alloy, or with a coating of synthetic resin.

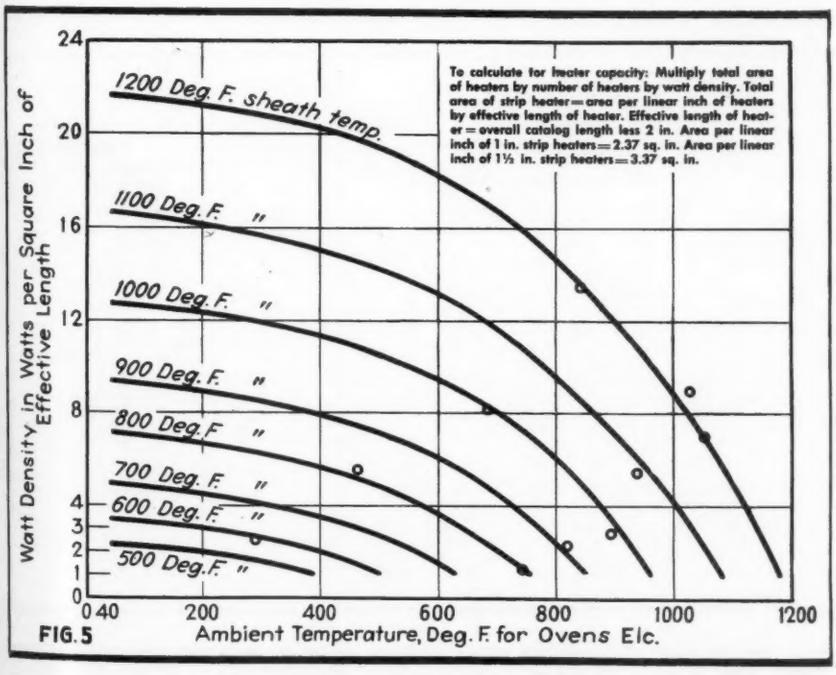

To calculate for heater capacity: Multiply total area of heaters by number of heaters by watt density. Total area of strip heater = area per linear inch of heaters by effective length of heater. Effective length of heater = overall catalog length less 2 in. Area per linear inch of 1 in. strip heaters = 2.37 sq. in. Area per linear inch of 1½ in. strip heaters = 3.37 sq. in.
1200 Deg. F. sheath temp.
1100 Deg. F. "
1000 Deg. F. "
900 Deg. F. "
800 Deg. F. "
700 Deg. F. "
600 Deg. F. "
500 Deg. F. "
Watt Density in Watts per Square Inch of Effective Length
0 40 200 400 600 800 1000 1200
Ambient Temperature, Deg. F. for Ovens Etc.
FIG. 5

Fig. 5—Density in watts per square inch of Chromalox strip heaters operating at 500 to 1,200 deg. F. sheath temperatures for various ambient temperatures of still air

Installing the Unit

Many of the details of installation must necessarily be worked out while the selection of the unit is being made. In the actual installation the problem divides itself into three more or less distinct parts. First, the transfer of heat from element to work must be accomplished efficiently; second, the heat must be confined to the desired area with little waste; third, the temperature must be controlled so as to be maintained at the desired level.

The importance of providing for the most rapid and efficient transfer of heat consistent with the desired results has been noted. In contact heating this means close fit, 0.004 in. clearance per inch of diameter, between cartridge unit and drilled hole; adequate clamping of strip heaters or ring units to heated part. In the case of immersion heaters, agitation of viscous liquids, prevention or removal of scale formation on heater blades will do much to insure satisfactory operation. In heating rooms or ovens forced convection of air will permit the use of higher ratings in a given size heater.

Economy and comfort usually demand that heat insulation be provided for applications where temperatures exceed 150 or 200 deg. F. Where heaters are operated continuously, domestic water tanks for example, it is often economically desirable to insulate at temperatures below this range. Consideration of the relative importance of radiation losses to other heat requirements will guide in determining the amount and type of insulation.

Insulating material should never be placed directly in contact with the surface of the heating unit because of the danger of building up excessive temperatures in localized areas. For example, to insulate an air heater, use a

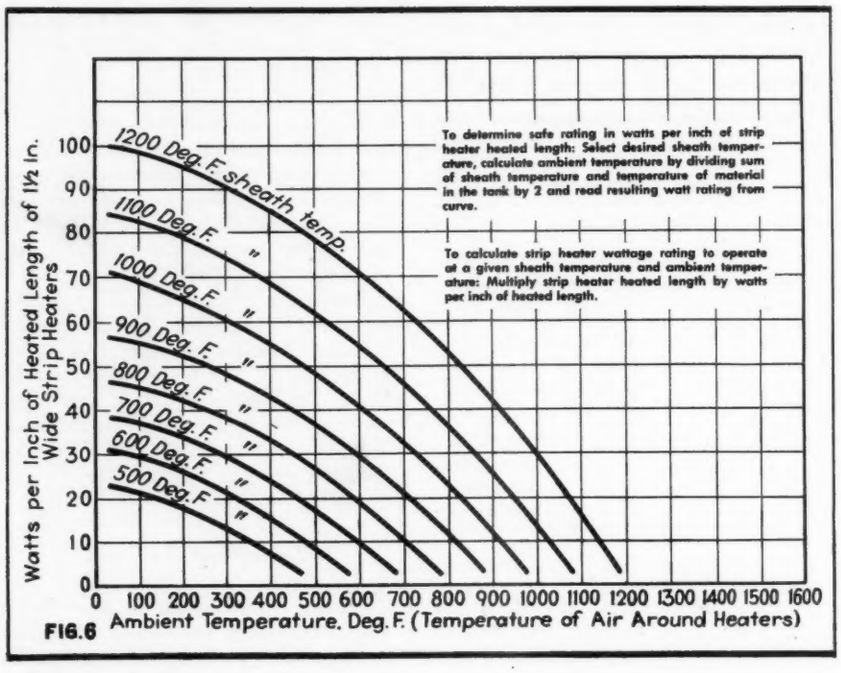

Watts per Inch of Heated Length of 1½ in. Wide Strip Heaters
100
90
80
70
60
50
40
30
20
10
0
1200 Deg. F. sheath temp.
1100 Deg. F. "
1000 Deg. F. "
900 Deg. F. "
800 Deg. F. "
700 Deg. F. "
600 Deg. F. "
500 Deg. F. "
To determine safe rating in watts per inch of strip heater heated length: Select desired sheath temperature, calculate ambient temperature by dividing sum of sheath temperature and temperature of material in the tank by 2 and read resulting watt rating from curve.
To calculate strip heater wattage rating to operate at a given sheath temperature and ambient temperature: Multiply strip heater heated length by watts per inch of heated length.
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600
Ambient Temperature, Deg. F. (Temperature of Air Around Heaters)
FIG.6

Fig. 6—Sheath or surface temperatures of 1½ in. wide strip heaters clamped to tank or pipe, for various ambient temperatures and wattage ratings per inch of heated length. Heated length of strip heaters shorter than 30½ in. is 4 in. less than overall length; strip heaters 30½ in. long or longer have heated length 5 in. less than overall length; 1½ in. wide strip heaters have 3.45 sq. in. of surface per linear inch; 1 in. wide strip heaters have 2.31 sq. in. of surface per linear inch

double shell to contain the insulation and allow an air gap between the inner shell or tank wall and the heating element. This will allow the air temperature surrounding the heating element to become uniform, and the heat absorbed by surrounding metal surfaces of tank wall will eliminate the danger of localized excessive temperatures.

It is seldom possible to select a heater capacity which will meet the demands for initial heating time and also hold required operating temperature under changing conditions of operation, so that some means of temperature control usually must be provided. Simplest perhaps, is the manual control afforded by merely turning the heaters on and off or by selecting any one of a number of predetermined wattage positions and a multi-heat switch. The surface unit of a domestic electric range, for example, may be turned to high heat for quick heat-up and then to one of the lower speeds for economical cooking.

The heating units in large applications may be wired into a number of separate circuits so that a part of them may be cut out after final operating temperature has been reached. With three-phase line supply a delta-wye switch is often used, the circuit being shown in Fig. 7. The banks of heaters may be connected in delta for quick heat-up or when unusual demands for heat must be met. When less heat is required the bank may be quickly reconnected in wye to operate at one-third rated wattage. In salt bath applications this process may be reversed. While the salt is in solid chunks, heat transfer between the elements and the material is at best uncertain and heaters are operated on reduced wattage to limit the temperature of the units to safe values. When the material has become molten, the switch may be turned to high heat to bring the material to final temperature rapidly, after which the heaters may be operated on full or reduced wattage, as occasion demands.

For most economical and uniform results, a thermostat is invariably used, often in conjunction with one of the switching arrangements mentioned above to reduce the load factor and drain on the power supply. A typical application is shown in Fig. 8. The thermostat may in some instances form an integral part of the heaters; usually it is more convenient to locate it separately. The activating element of the control is usually either a bi-metallic strip or a bulb filled with gas or liquid and, for best results, this member should be located as near as possible to that part of the device or material whose temperature must be closely regulated.

To summarize, almost every heating problem can be solved by use of electric resistance heating units, and it is possible to arrive at this solution by applying engineering fundamentals and common sense to the selection of the proper units. If the units are carefully chosen and thoughtfully applied, paying proper heed to watt density and basic physical laws, satisfactory results can be assured.

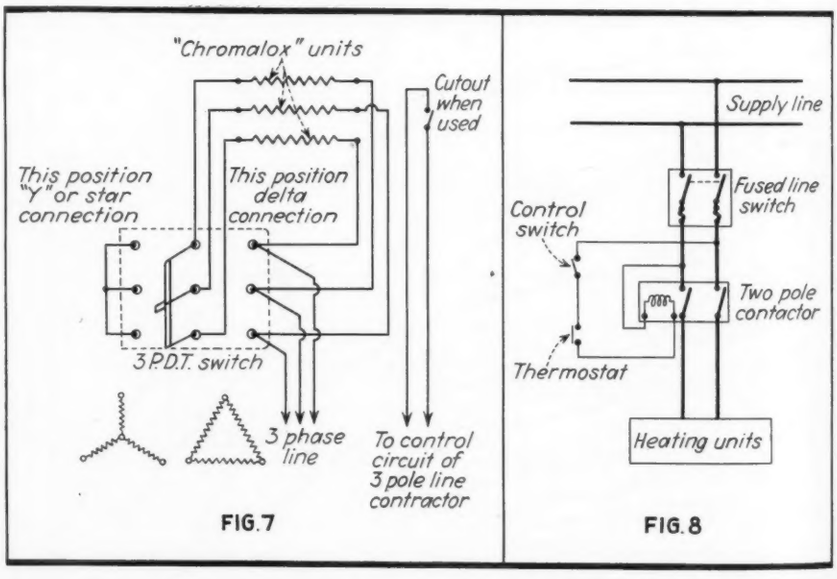


Fig. 7—Typical wiring diagram for three-phase power supply and using a delta-wye switch. Full heat is obtained on delta connection, one-third on wye or star connection. Fig. 8—Typical wiring diagram for electric resistance heater circuit using a thermostat and contactor

STUFFING BOXES—I

Pressure Sealing Devices for Rotary Shafts

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STUFFING BOXES, or seals, can be divided functionally into those which seal against hydraulic pressures and those which seal against gas pressures. All sealing arrangements, however, are based either upon the establishment of an impervious joint between two members not integrally connected, or by throttling down the operating pressure, which is accomplished by forcing the sealed medium to travel through a maze of small clearances in the sealing device. The simplest illustration of the impervious joint type seal is the flange union, whereas, a good example of the application of the latter principle is a labyrinth seal.

Regardless of the type of service, the usual stuffing box assembly for rotating shafts, in which the rotor and stator members maintain contact through friction, has for a basis of design some combination of both principles. The proof of the foregoing statement is founded upon two separate conditions, notably the existence of pressure gradients in stuffing boxes and, secondly, the fact that while labyrinth seals are designed for a predetermined amount of leakage, usually stuffing box design requires theoretical freedom from leakage.

From the viewpoint of construction there are two types of stuffing box assemblies. The first type, illustrated by Fig. 1, involves the application of a distorting or deforming force to a definite volume and shape of packing against the resilience of the packing, thus forcing the packing to seize the shaft and also the inside wall of the packing box. The second type, shown in Fig. 2, employs a rotating device attached to the shaft, in which a spring member exerts a deforming pressure against a material of low yield characteristics contained in the rotating assembly. The spring member also forces a rider member to ride with a predetermined pressure on a thrust loading bearing seal ring. The spring pressure exerted on the material in the rotating container forces the material to expand, thus accomplishing a seizing of the container and the shaft. The spring pressure also reduces the thickness of the lubricant film between the rider and seal ring to a minimum. The spring pressure also maintains a tight joint between the sealing ring and the floor of the box.

In the design of stuffing boxes of the type in which the packing is deformed by compression, the problems encountered are: the determination of the necessary gland pressure, the selection of the type of packing, and the method of jacketing the box if necessary. Three different methods of obtaining gland pressure are shown here. Fig. 1 shows the "bolted flange arrangement," while Figs. 2 and 3 illustrate respectively the "spring method" and the "screwed gland method." These are the methods in common use though they are not the only ones. The problem of the choice of packing materials or combinations must be approached in two ways, one consideration is the selection of packing having suitable chemical resistance to corrosion properties as well as mechanical properties which assure long life, the other consideration is the choice of a material that requires a minimum of gland pressure. The factors which promote resistance to chemical corro-

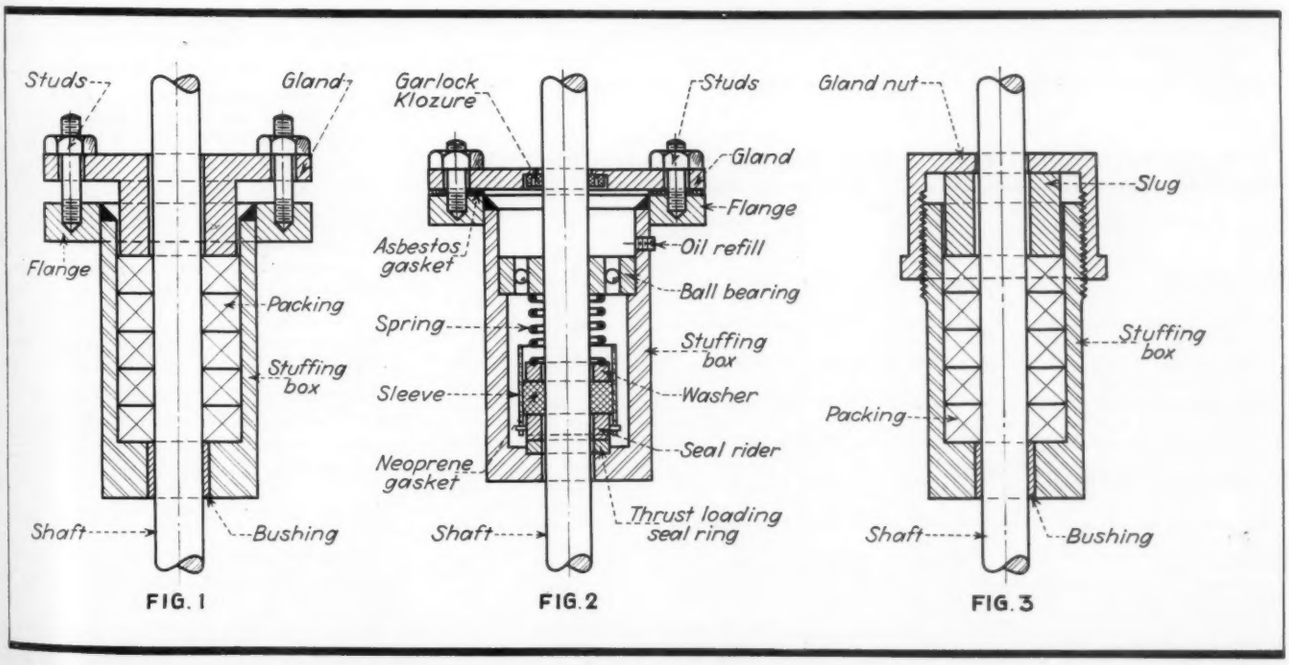


Fig. 1—Stuffing box in which a force is applied to distort or deform a resilient packing. Fig. 2—Rotating device attached to shaft with spring member which exerts a deforming pressure on packing. Fig. 3—Threaded gland nut type of stuffing box

sion are beyond the scope of this article, but may be briefly set forth by saying that the matrix of the packing and any imbedded or impregnated materials or compositions should be chemically inert to the medium to which the box is exposed. Some desirable mechanical properties for a packing are:

1. Low coefficient of friction between the packing and the shaft.
2. Insolubility of the packing lubricant in the medium against which the box works.
3. High resiliency.
4. Absence of ingredients in the packing composition that could impair the working surface of the shaft.

The mechanical properties of the effective portions of a packing combination can be altered by the inclusion of relatively inert members in the packing combination. Thus, the inclusion of lantern ring arrangements may effectively reduce the coefficient of friction of the packing with the shaft, and the inclusion of dummy or bull rings may, by effecting the equal distribution of the gland pressure, prevent the excessive wear of any single portion of the packing or the uneven distortion of the packing shape. When determining whether or not a box will require a water jacket two factors are considered, these are the power loss in the shaft because of friction and the conditions affecting the heat radiating capacity of the box as determined by its shape and ventilation conditions.

A detail of stuffing box design which deserves some attention is the use of a bushing and its location if used. Figs. 3 and 4 show two different types of boxes having alternate positions for a bushing or bearing. The selection and design of a bushing member are often complicated by the corrosion properties of the medium against which the box works. When corrosive mediums are present the design may require the provision of a seal to prevent the medium from attacking the bushing; such an arrangement is shown in Fig. 5. Where the bearing load to be assumed by the packing is small the bushing member may be eliminated from the design.

When serving as a bearing the bushing limits the deflection of the shaft in the box to a minimum thus increasing the life of the packing and reducing the required gland pressure. The factors which enter into the design of the bushing member are the allowable bearing pressure P for the two metals in contact as determined by the condition of lubrication, the diameter d of the shaft, the length l of the bearing, and the radial load L on the bushing.

$$P = L/(ld) \qquad (1)$$

The gland load in a stuffing box can be calculated from three equations. Determine the minimum force F_1 required to deform or yield the packing

b = effective packing yielding width, in.
C = centerline diameter of packing, in.
y = yielding limit of packing, lb. per sq.in.

$$F_1 = \pi\, b\, C\, y \qquad (2)$$

Calculate the force F_2 required to compress the packing under pressure

m = unit compression factor
p = pressure of medium against which box works, lb. per sq.in.

$$F_2 = 2\, \pi\, b\, m\, p\, C \qquad (3)$$

Typical values of y and m are given in Table I for various materials.

Assuming that the hydrostatic end force U acting in the box operates over an area bounded by the shaft and by the center line diameter of the packing,

$$U = \frac{\pi}{4}\,(C^2 - d^2)\,p \qquad (4)$$

The greater of the values given by Equations (1) or (2) plus (3) can be taken as W, the gland load.

When a screwed gland is used to obtain gland pressure, the gripping length of threads l_1 required to prevent stripping of the threads on the box body or

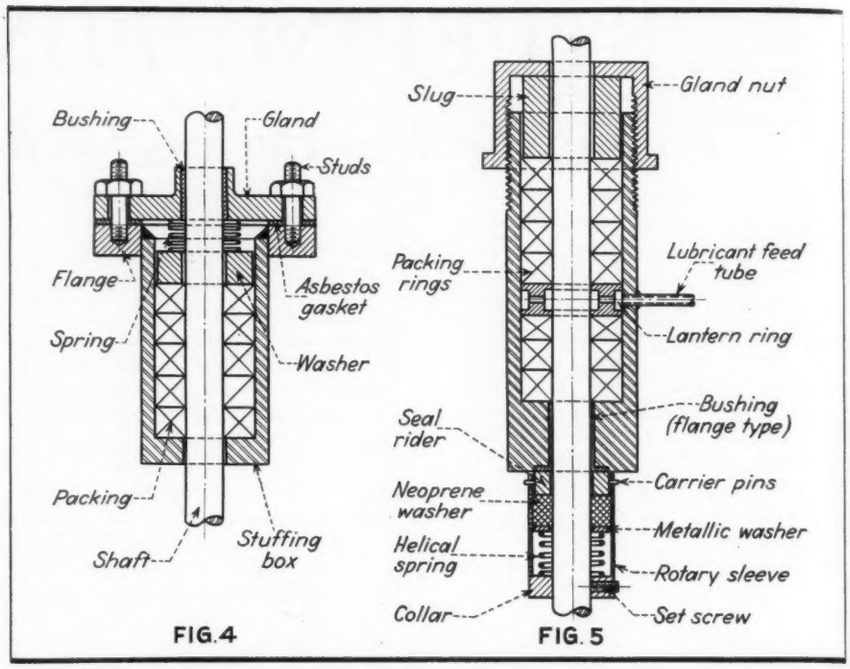


Fig. 4—Spring loaded stuffing box with straight bushing for shaft bearing in gland
Fig. 5—Threaded gland box with flanged bushing for shaft bearing in floor of box

Table I—Typical Yield Limits and Compression Factors

Types of Packings	y	m	Types of Seal Rings	y	m
Soft asbestos	200	0.25	Rubber	800	1.50
Soft asbestos composition	250	0.30	Asbestos cloth	8,000	2.50
Semi-metallic comps	300	0.40	Aluminum	10,000	4.50
Hemp and lubricant	250	0.30	Bronze	8,000	4.50
Rubber rings	800	0.50	Steel	18,000	5.50
Rubber comps. and inserts	1,000	1.50	Monel	14,000	4.50
Close-weave asb. comp	1,000	1.50	Carbon rings	1,500	2.50
Leather rings	1,200	2.00	Babbitt rings	2,500	4.00
Babbitt foil and rings	2,500	2.50	For all cases, b will equal the width of ring or packing divided by 2		
White metal foil and rings	3,000	2.50			
Felt rings (medium)	300	0.50			

in the gland nut can be calculated from

D_1 = dia. of thread in gland nut, in.
S_s = allowable shearing stress for the weaker of the two materials in contact, lb. per sq.in.

$$l_1 = \frac{W}{\pi D_1 S_s} \qquad (5)$$

From 1 to 1½ in. additional length of thread for adjustment in taking up the slack in the packing is advisable.

Where a bolted flange arrangement is used for effecting the gland pressure, the minimum bolting area A_1 can be calculated from

S_b = allowable stress in tension for bolt material, lb. per sq.in.

$$A_1 = \frac{W}{S_b} \qquad (6)$$

After selecting the minimum number of bolts n_1 whose combined root areas approximate the minimum bolting area A_1 solve for the bolt load W_1 from

$$W_1 = n_1 \times a_1 \times S_b \qquad (7)$$

Then if W is the gland load and h_1 is the lever arm. or the radial distance from the point of application of the force W to center line of bolt-circle, and M_1 is total moment on box flange

$$M_1 = W \times h_1 \qquad (8)$$

With D_2 representing the internal diameter of the box in inches, the unit flange moment M_2 can be calculated from

$$M_2 = \frac{M_1}{D_2} \qquad (9)$$

Assuming a value for the tangential stress S_1 in the flange sufficient to obviate the necessity for considering the radial stress in the flange or the shifting of some part of the longitudinal stress in the box wall to the box flange (this value may be set at 8,000 lb. per sq.in. for cast steel or 12,000 lb. per sq.in. for forged steel), the required box flange thickness t_1 can be calculated from

$$t_1 = \left(\frac{M_2 \times Y}{S_1}\right)^{1/2} \qquad (10)$$

where Y is a factor obtained from Fig. 6 corresponding to the ratio of the box flange diameter D_F to the inside diameter D_2 or $K = D_F/D_2$. Similarly the thickness of the gland flange can be computed from the same equation where the value of Y is that corresponding to D_F/d the K value obtaining for the gland. The unit moment for the gland flange is, of course, determined in the same manner as that for the box flange. These calculations for the box and gland flange thicknesses are based on the assumption that the distribution of the flange moment is uniform. Whether or not the flange moment will be uniformly distributed depends upon the bolt spacing k, flange thickness required t_1 and the size of bolts z required to take the load. To adjust the flange thickness for non-uniform moment distribution the flange thickness as previously determined should be multiplied by the following factor when the value of the factor is greater than one,

$$\left(\frac{k}{2z + t_1}\right)^{1/4} = \text{factor} \qquad (11)$$

However, the value for the box flange thickness thus arrived at and checked may still be unacceptable if capscrews or studs engage threaded holes in the flange. When this condition exists, the minimum flange thickness should be calculated from

$$t_1 = \frac{W_1}{n_1 \times \pi z \times S_s} \qquad (12)$$

Let S_2 be the allowable longitudinal or axial stress in box wall, then the thickness of the box wall t_2 is given by

$$t_2 = \left[D_3 - \left(D^2 - \frac{W}{\pi S_2/4}\right)^{1/2}\right] \qquad (13)$$

Where the box is jacketed, the box wall thickness may also be calculated to resist the collapsing pressure exerted by the cooling medium. Usually the value thus arrived at will be insignificant in comparison to the value obtained as necessary to withstand the longitudinal stress in the box wall, therefore the value obtained by Equation (13) should be employed.

The thickness of the floor portion is usually determined by the length of the bushing member incorporated into the floor of the box. The force F_3 borne by the floor of the box is

$$F_3 = W - U \qquad (14)$$

The unit working pressure which is then stressing the member is

$$\frac{F_3}{\pi (D_2^2 - d^2)/4} \qquad (15)$$

Hence, where p is the pressure in lb. per sq.in. inside the kettle or container to which the box is applied and P_1 is the pressure on box floor caused by gland pressure, then

$$\pm (p - P_1) \qquad (16)$$

is the working pressure which is considered in the formulas approved by the A.S.M.E. for flat heads of the integrally attached type, to wit

$$t = d\sqrt{C\,P/S} \qquad (17)$$

Hence the minimum floor thickness t_3 may be obtained from

$$t_3 = D_3\sqrt{\frac{0.25 \times (p - P_1)}{S}} \qquad (18)$$

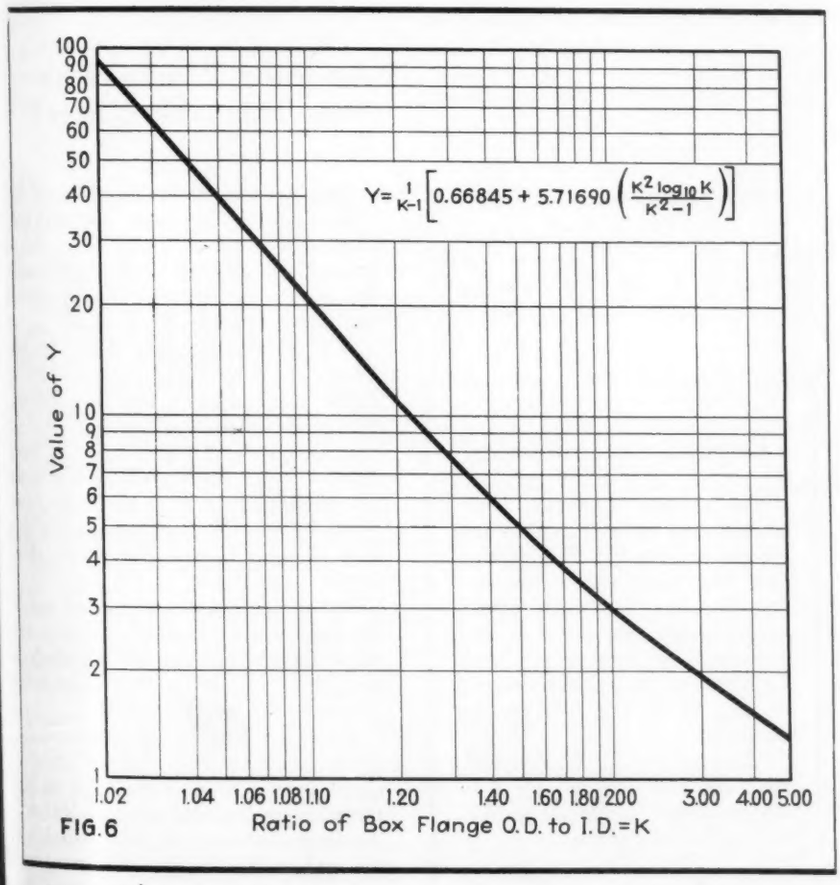


FIG. 6

Fig. 6—Y factors for various ratios of box flange diameter to the inside diameter

(To be continued in November P.E.)

Question and Comment

New Feature—"Causes and Cures" Evokes Many Comments from Previewers

[*Editor's Note*—Some time ago we conceived the idea for a new monthly feature in PRODUCT ENGINEERING—a page called "Causes and Cures" wherein design engineers present examples of design faults and tell how they were corrected. "Causes and Cures" makes its first appearance on page 411 of this number. In order to get a final check on our idea and possible suggestions for further improvements, we sent out preprints to a few of our readers asking them what they thought about it. Some of their comments are briefed below.

We were able to send out only a small number of preprints, but now all of our readers have a chance to look at "Causes and Cures." The editors will appreciate comments pro and con from anybody and everybody. If you like "Causes and Cures" we want to know it. If you have suggestions for improving it, we want to know that too. Incidentally, we hope that many more of our readers will join the family of PRODUCT ENGINEERING contributors through this new department.]

Bound to stimulate thought

We are pleased to see that you are introducing the new feature "Causes and Cures." It is bound to stimulate thought in our designers whether the cases discussed are applicable to our work or not. The examples do illustrate fundamentals which cover innumerable applications and yet are not recognized until they are brought out in discussion.

—F. D. MILLER
Chief Engineer
Mixing Equipment Company, Inc.

Water over the dam

We believe this is a splendid idea, and although we also had experience along this line, since this is "water over the dam" we at the present time have no contribution to make.

—R. NORDQUIST
Chief Draftsman
American Can Company

[*Editor's Note*—Some of your experiences may be "water over the dam" as far as you are concerned, but not to other design engineers. Don't hesitate to send in your experiences from the past. If it is new to our readers, it is acceptable.]

Answer to stumpers

No one man or small group of men can know all of the answers, and if we have an opportunity to read the answers to "stumpers," our engineering education is bound to be enhanced.

—E. W. ALLARDT
Chief Engineer
The Yoder Company

Suggests grouping by subject

"Causes and Cures" is very interesting and I think this should appeal to quite a number of your readers. We suggest, however, that you try to group them, after you have collected enough, into related subjects.—THOMAS BARISH
Assistant Chief Engineer
Marlin-Rockwell Corporation

Consider failures—not successes

You are to be congratulated on your idea of the monthly feature "Causes and Cures." We are all inclined to publicize our successful efforts more than our mistakes. Consideration of our failures and the methods used to overcome errors are of much greater interest and value.

—W. M. FLEMING
Chief Engineer
Worthington Pump and Machinery Corporation

Good idea—if

Your new monthly feature is a good idea if you can succeed in getting enough good material to keep it going. The tendency will be, I think, to get too many elementary cases which are so obvious that they will be of no interest to experienced designers.

—M. S. LEONARD
Chief Engineer
B. F. Sturtevant Company

[*Editor's Note*—We recognize this dangerous possibility. It won't happen if you readers send in some of the good material we know you must have.]

Engineering Societies

This month PRODUCT ENGINEERING inaugurates another new feature page called "Engineering Societies" which summarizes current activities and plans of the many engineering societies and manufacturers associations. Look for it this month and every month on page 4, in the front of the magazine.

"Engineering in Washington" has been moved from page 4 to the News and Summaries section, page 425 of this number.

Anything Wrong With This Turntable Drive?

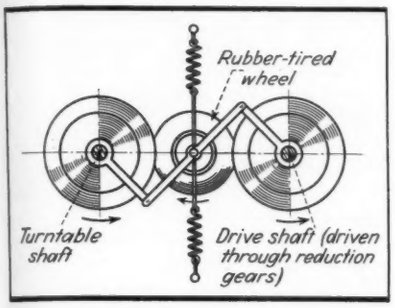
To the Editor:

The problem recently raised in the "Question and Comment" section, concerning a constant speed drive for a turntable to eliminate a heavy flywheel, has aroused my interest. For precision turntables, the problem seems to be that of eliminating very slight fluctuations caused by such as imperfections in the gear reduction, etc. I am submitting herewith for the criticism of your readers, an idea for getting rid of these fluctuations. I frankly admit that I am not thoroughly acquainted with turntable drives, and have never taken this idea of mine beyond the purely theoretical stage.

The device consists simply of a rubber-tired wheel "floating" between two small flanged wheels, one of which is pinned to the drive shaft, the other pinned to the turntable shaft.

From the diagram herewith, if the drive wheel suddenly speeds up, any slight inertia which does exist in the turntable resists this acceleration, and the forces between the drive wheel and the rubber wheel tend to push the latter downward. This movement causes the

links to squeeze the rubber wheel harder against the turntable wheel, thus reducing the radius of rubber on that side, and at the same time increasing the radius of the rubber on the drive wheel side. These changes in radius counteract the sudden acceleration. When the drive returns to normal speed, the elastic forces in the rubber will cause the center wheel to return to its normal position. When the drive wheel suddenly decelerates, the reverse action will take place. Thus the rubber



wheel will bounce back and forth to compensate slight fluctuations.

Of course, considerable experimentation may be necessary before the right cross-section of the rubber tire and the correct linkage are determined. Also, it may be found necessary to return the rubber wheel to neutral by means of steel springs or some other balanced device. It looks okay—but is it?

—J. K. HARRIMAN
Hartford, Conn.

The Myth and the Facts Of Mass Production

To the Editor:

While browsing through the Chicago *Daily Tribune* for July 27, I ran across an editorial entitled "The Myth and the Facts of Mass Production" wherein the editor has grasped and placed before the public a great truth. The editor writes:

". . . fundamental of the mass production system as it operates in American industry is that it is geared to the price system. The designers do not have the final word. They may bring forth a beautiful idea, but when the production men start to figure its cost and find that it is impracticable, either because it requires too expensive material, or because the machinery to do the job is not immediately available, or because the operations necessary require too much labor—then the beautiful idea goes out the window. This is not true of government orders. Instead of setting forth requirements and allowing production men to meet them in a practicable manner, the designers have the final word on every last thread of every last bolt. Naturally, the government pays for this, in money and in delayed deliveries.

"If mass production is to rearm America, three things must be done: Orders must be placed in large enough quantities to permit manufacturers and train employees in the special skills needed. There must be no change in designs once they have been approved. And the production men, and not the designers, must be given the last word. If the Army and Navy keep insisting on perfection they will end up with no weapons at all, or at least an insufficient quantity of them."

Although I am a design engineer, I do not take exception to the *Tribune's* belief that the production man's last word should be placed over that of the design engineer. Interpreted broadly, the statement means that the government right now ought to stop thinking of small-order production as merely another phase of design. Somewhere along the road to preparedness, the government wagon has got to be stopped long enough for the production man to climb on and take over the reins. The government must "freeze" what acceptable designs we already have developed for tanks, planes, armored cars, etc., and be satisfied with them.

Design engineers will have to stop trying to dribble those "last little improvements" into present military designs. They will have to wait until mass production tools have turned out the first 1,000 planes, 500 tanks, or until the production man says "go" to ideas calling for new tools and jigs.

Anyway, the designer will be busy enough planning for airplane No. 1,001 while the first 1,000 are being built—if this country is to produce enough to fill out its preparedness program and still keep its claimed leadership in military design.

—BURTON FIELD,
Oak Park, Ill.

The Designers

The designer bent across his board,
Wonderful things in his head were stored.
And he said as he rubbed his throbbing bean,
"How can I make this thing tough to machine?
If this part here were only straight
I'm sure the thing would work first rate.
But 'twould be so easy to turn and bore
It never would make the machinists sore.
I better put in a right angle there
Then watch those babies tear their hair.
Now I'll put the holes that hold the cap,
Way down in here where they're hard to tap.
Now this piece won't work, I'll bet a buck,
For it can't be held in a shoe or chuck.
It can't be drilled or it can't be ground
In fact the design is exceedingly sound."
He looked again and cried—"At last—
Success is mine, it can't even be cast."

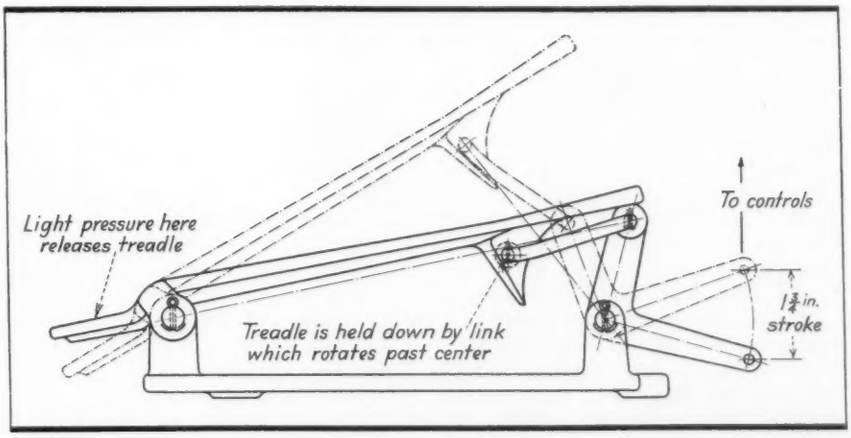
—KEN LANE
Lynn, Mass.

[*Editor's Note*—Perhaps this poem expresses the tool engineer's opinion of the designer. At any rate, it was printed on the back of the program for the Annual Outing of the Boston Chapter of A.S.T.E.]

Link Swings Past Center To Lock Treadle Position

To the Editor:

We believe that the Hardinge self-locking treadle shown herewith is an interesting addition to the collection of pedal and foot-operated lever arrangements presented by Fred Adams in a



recent series of PRODUCT ENGINEERING articles.

The treadle is self-locking in the down position. This locking action is obtained by a link which, when the pedal is fully depressed, swings past center such that the pressure of the spring-returned control rod acts to hold the treadle down. Slight pressure at the heel section of the pedal releases the treadle, which then freely returns to the up position. A slight bend in the link comes to bear against a stop on the cast treadle to prevent overtravel on the return stroke.

The complete device is simple in construction, requiring only three castings, the treadle, the base and the bell crank; and a link made from bent steel rod. —D. R. LAUX,
Hardinge Brothers, Inc.

Can You Work This One?

H. E. SMITH

Solution to August problem—

Count Your Cards

While dealing regularly in bridge, South dropped some undealt cards on the floor. He observed that the number of cards on the floor was two-thirds the number he had dealt to West, and the number dealt to East was two-thirds the number still in his hand. The problem was, how many cards had been dealt? If you dive into a little guesswork and/or simple calculations, you come up with the answer of 34 cards dealt, 9 to West and North, and 8 to East and South. There were 6 cards on the floor and 12 still undealt.

This month's problem—

How Deep the Pond?

A man wanted to find the depth of a small pond on his land, but had no way to get out to the center to take soundings. However, he noticed that a waterlily, growing straight up from the bottom, had its blossom exactly one foot above the surface. One day a strong wind blew this waterlily over until it was level with the water surface, at which time the blossom was six feet from the point on the surface at which it first stood. Assuming that the stem remained straight, what was the depth of the pond?

Case Histories in Patent Law

H. A. TOULMIN, JR.

(EDITOR'S NOTE: The purpose of these Case Histories is to give a better understanding of the patent law in the public interest. The author advises that actual cases should be submitted to your own patent attorney.)

No. 18

QUESTION: How can the activities in patent matters of a competitor be checked before his patent applications issue into patents in the United States?

ANSWER: While United States Patent Office applications are secret and their contents are not revealed until the patents are actually issued, yet there are a number of ways of getting a fair idea of what your competitor is doing patentwise.

If the competitor follows the practice of having his inventions assigned to him, the serial number and title of the invention may appear upon the assignment records of the United States Patent Office, which are open to anyone's inspection. This will give a pretty fair hint of the subject matter of the invention and the date when the application was filed.

But more important still are the records of foreign countries, because foreign countries require the publication of applications when they are ready for allowance to give a period for opposition and other legal proceedings.

For instance, a careful perusal of the publications of applications for Letters Patent, which are preliminarily published by the British Government, will enable you to determine exactly the general subject matter from the drawings and specifications of the proposed patent that the British Government is going to allow, unless there is an opposition. The result is that a corresponding application in the United States can be seen disclosed in the British application. This is due to the fact that it takes longer to prosecute applications in the United States than in Great Britain where they are under certain time limits requiring their early allowance. As a consequence, applications in Great Britain often mature in patents many months and sometimes years before their corresponding counterparts in the United States appear.

Likewise, in Canada, many patents are issued prior to the corresponding patent applications being issued into patents in the United States. A careful check of the Patent Office Gazette in Canada enables you to see the drawing and other descriptive data, which will give you an idea of the nature of the invention. Unfortunately, Canada does not publish its patents, so that if you desire a copy, you will have to purchase a duplicate in typewriting of the specification and a duplicate of the drawing. This is often very expensive. But where the matter is worth it, a complete disclosure of the Canadian patent oftentimes reveals exactly what is pending in the U. S. Patent Office.

Likewise, in Germany there is a period of publication by which the application is laid open to public inspecton for opposition. Here is another fruitful source of information.

Somewhat similar practices are followed in other European countries and a careful check of their records, their publications and Official Gazettes enables the astute competitor to have a pretty fair idea, sometimes many months or years in advance of the actual event, of what is pending in the Patent Office in the name of a competitor and what will be issued.

The virtue of following such ideas is this. It is possible to thereby call upon the Patent Office to declare interferences with your applications that are pending in the United States Patent office, which might not otherwise come to the attention of the Patent Office. By having such interferences declared, the question of who was the first inventor of the idea can be settled in the United States promptly without the expense of extended litigation at a later date. Then, again, if a competitor has developed an idea, which, when ultimately patented in the United States, will cover the apparatus or the process that you are practicing or using, then this knowledge will enable you to make changes in time to avoid litigation.

These are all steps in "preventative law" which should be taken by every alert manufacturer. Much of the expense that results from legal proceedings is caused by failure to take these normal precautions which the law provides, but which so many manufacturers neglect until they are forced to enter into expensive litigation or Patent Office interferences. Then they complain of the unnecessary burden of litigation and the complications that result, not to speak of lawyers' bills.

News and Summaries

High-Speed X-Ray Tube Takes Radiographs At Millionth-of-a-Second Exposures

May make possible the motion picture study of internal strains in fast-moving machine parts, say Westinghouse research engineers

MILLIONTH - OF-A - SECOND radiographic exposures have been successfully made by a newly developed cold-cathode ultra high-speed X-ray tube in Westinghouse Lamp Division's Research Laboratories at Bloomfield, N. J. According to Dr. Charles M. Slack, Westinghouse research physicist who recently described the new radiograph to members of the American Physical Society, development of the tube extends the possible usefulness of the X-ray science into wide new fields of engineering. It may make possible X-ray motion pictures and the study of internal strains in rapidly moving parts of motors and machinery, enabling man literally to see into rapidly moving opaque objects and study the effect of sudden forces on such objects.

As developed in the laboratory, the new X-ray tube contains three elements: a standard anode; a small oval-shaped metal cathode; and an auxiliary electrode which serves as a "trigger" to start the discharge of electrons when the tube is activated, but immediately thereafter assumes the role of focusing cup. The trigger element permits anode and cathode to be separated sufficiently to forestall formation of a low-voltage arc discharge which would prevent production of X-rays.

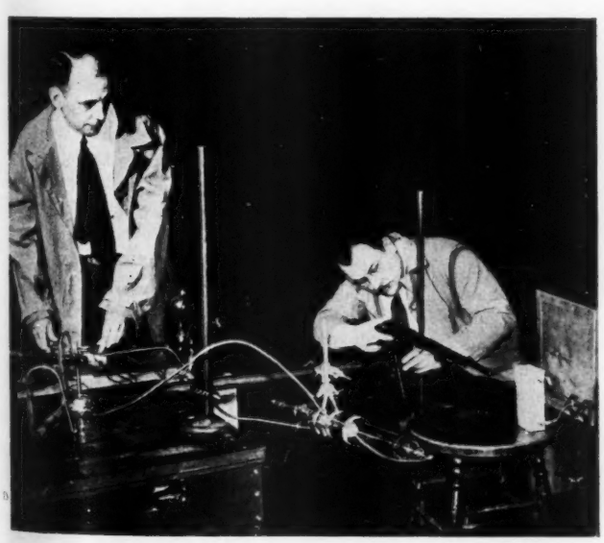
The circuit works this way: Capacitors are charged to about 90,000 volts. A spark gap in series with the tube withholds this voltage from the tube until an impulse is given from an auxiliary timing circuit. When the timing circuit is broken, such an impulse is created and is added to the main voltage of the capacitors, causing the capacitors to discharge across the gap and through the tube.

To create at the desired instant the impulse which causes the discharge, a strand of fine wire in the timing circuit is placed just ahead of the golf ball, baseball, or other object to be radiographed. The X-ray tube is placed at one side, opposite the cassette containing the film, so that the object to be pictured is directly between tube and film, as near the film as possible. The object moving at high speed breaks the wire and interrupts the circuit, dissipating the negative charge on the grid of a thyratron tube in the timing circuit. This permits a capacitor in the timing circuit to discharge through the primary of an induction coil, creating a voltage impulse sufficient to discharge the capacitors in the tube circuit.

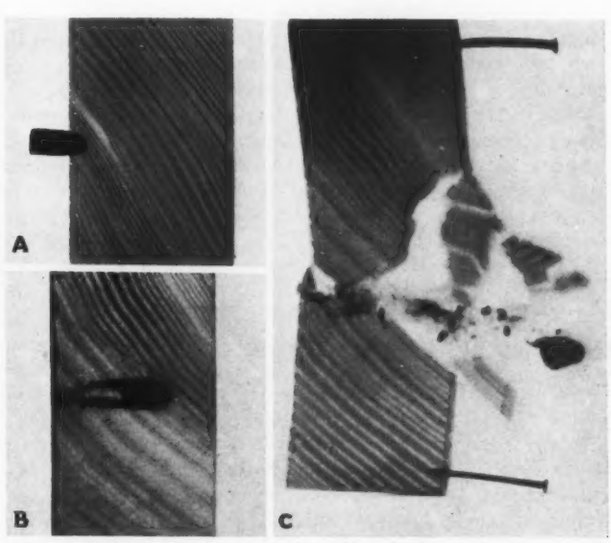
At that instant, the tube receives a momentary "jolt" of some several hundred to approximately 2,000 amp. at between 90,000 and 100,000 volts. Conventional types of X-ray tubes are usually operated with ½ amp. or less current. The momentary surge of X-rays produced by the jolt exposes the radiograph. Exposure time, approximately one microsecond, has been measured from a radiograph of a high sped bullet in flight through the air.

Key to the ability of the newly developed tube is the auxiliary electrode, which harnesses and puts to work a once avoided phenomenon known as cold emission, which is caused by erratic flow of current from parts of the tube other than the heated cathode or filament.

In laboratory experiment, research engineers have taken millionth-of-a second radiographs of moving bullets,



Using their new high speed X-ray tube, Westinghouse research engineers Dr. Charles M. Slack and L. F. Ehrke prepare to "shoot" a radiograph of a bullet passing through a wood block



Radiographs of .22 bullets blasting their way through wood, taken with action-stopping millionth-of-a-second exposures. Note partial sealing of hole in B, *literal explosion in* C

golf balls being driven from a tee, baseballs being batted, and numerous other objects. Many possible applications, such as radiography of metal, will require more powerful tubes and equipment than those used in the laboratory.

Billion Dollars Yearly Needed for Research

URGING every industrial company in the United States to spend 2 per cent of their gross income for research, Dr. Karl T. Compton, president of the Massachusetts Institute of Technology, stated that this needed total would amount to more than a billion dollars a year—probably five times as much research as is being done now.

"The future of America depends largely upon industrial research," said Dr. Compton. "Although many companies have done a research job of which America can be proud, research is still one of the least developed resources of the nation. National defense needs make it particularly urgent in the months ahead for America to lead the world in research."

In June, 188 companies were surveyed by the National Association of Manufacturers Advisory Committee on Scientific Research, of which Dr. Compton is chairman. While the results of the inquiry revealed that ten companies spent over 10 per cent of their gross income for research, the broad average of all the surveyed companies' expenditures was 2 per cent, the figure which Dr. Compton believes necessary for all of the nation's industry.

Manufacturers in the aviation category were found to be among the most research-minded, judging from the budgets reported. Among the top ten were two manufacturers of airplanes and airplane parts, two machinery manufacturers, a manufacturer of railway equipment, an electrical equipment company, a refiner of ores, a manufacturer of glue, a combustion and chemical engineering company, and one manufacturing chemist.

Bureau of Standards Reviews Synthetic Rubbers

FACTS AND FIGURES on synthetic rubbers, which have now been in commercial use for ten years, are published in a new Bureau of Standards Circular C427 entitled, "Synthetic Rubbers: A Review of Their Compositions, Properties, and Uses," by Lawrence A. Wood.

According to Mr. Wood, the most active research has been carried on in Germany, Russia and the United States. In the first two countries the primary aim seems to have been to duplicate, or nearly duplicate the properties of natural rubber. In the United States, on the other hand, the apparent objective has been to produce a superior product, so as to justify the higher cost which is about three or four times that of natural rubber. Recent international events, however, are changing the American viewpoint.

In Germany and Russia synthetic rubber is used to displace natural rubber in all its applications. In other countries, especially the United States, only those applications for which natural rubber is deficient have, so far, been of importance. Synthetic rubbers can be made to show great superiority over natural rubber in resistance to liquids, particularly petroleum products, and to deterioration by exposure to light, heat, ozone, and oxygen.

The survey lists about 30 varieties of synthetic rubber, almost all of which are in present commercial production. The varieties are grouped in six general classes, according to chemical composition, and the discussion follows this classification. Published values of the properties of the different varieties of synthetic rubber are summarized in comparative form. A bibliography of over 200 references is given, listing scientific literature on this subject during the past decade.

Flair for reflection. Taking place of flares to warn motorists of stalled vehicles, this new reflector is inclosed in metal covers which lock open to serve as base. Red Lucite disk, molded according to Stimson principle of retrodirective reflection, needs no mirror, is easily seen from head-on or angular approaches in either direction.

Plans Foundry Research At Battelle Institute

A PROGRAM of foundry research, to be conducted at Battelle Memorial Institute, is now being planned by the recently organized Gray Iron Research Institute. Chartered with ten member companies as a non-profit corporation under Ohio law, the Gray Iron Research Institute will engage in scientific research and technical development work for the gray iron industry.

As a first part of the program it is planned to conduct studies of the fundamental principles of the cupola melting of gray cast iron, using the combined laboratory facilities of the fuels and metallurgical laboratories as well as the experimental foundry at Battelle. It is expected that these investigations will provide the groundwork for more accurate control of metal quality and composition and that the technical information obtained in the operation of the experimental cupola will indicate to the member foundries changes in practice and degree of control necessary to obtain the highest quality metals at the lowest operating costs.

Experimental program will be under the direction of Dr. C. H. Lorig, supervising metallurgist, and Mr. R. A. Sherman, head of the fuels division of Battelle Memorial Institute.

Do You Know That—

COLORS of porcelain enamel coatings are being checked with electric gages which measure the thickness of coating; the color varies with thickness. (23)

CEMENTED CARBIDES have dropped in price more than 60 per cent since 1930. Lower prices are expected to boost current armament program through greater use as cutting tools to increase production per machine. Also expected is greater use in wear- and erosion-resistant parts. (24)

LEANING WHEEL TIRE has been developed to withstand wear and tear on road machinery where wheels lean over for operation in ditches and on sides of embankments. Circular grooved tread resists side-slip; sidewall tread has radial cleats for easy rotation in mud while the wheel is leaning. (25)

FABRICS can be rendered electrically conductive by a new impregnating compound containing colloidal graphite. Coating hardens on exposure to light after application. (26)

ENGINEERING IN WASHINGTON

McGRAW-HILL WASHINGTON BUREAU, *PAUL WOOTON, CHIEF*

Aluminum takes the spotlight as air war and plane building grows. The Defense Commission has examined the aluminum situation. Executives of federal agencies did not admit any concern over what they found. Nevertheless, on the heels of a $25,000,000 appropriation, requested by the Administration, for expansion of TVA power facilities, came an RFC loan to the Reynolds Metal Company for construction of an $18,000,000 virgin aluminum plant to be in TVA territory. This will be the only domestic competitor of the Aluminum Company of America in production from bauxite. It should be noted that the government is supplying about 5/6 of the risk capital for the Reynolds plant. Watch for politics.

Garand rifle rumpus was only asleep, not dead. Many outspoken observers of Army's selection of the Garand, and refusal to go into experimental production with the lately-submitted Johnson, say "it stinks." Army sticks to its answer that, though improvements are constantly coming out, you can't get into mass production and equip an army by quibbling and changing from one thing to another. Meanwhile, the Marines say they'd rather have the 1903 Springfield than the Garand. The leathernecks have been testing a new design by Winchester.

To keep secrets of defense inventions and to prevent foreign governments from reading patent details to their hearts' content, a bill has been passed by the House, and sent to the Senate, which would authorize the patent commissioner to keep matters of defense importance under lock and key.

Talk about tanks will be heard from now on. Some engineers think a tank is just a caterpillar with a turtleback and guns inside. But the Ordnance boys tell us different. A track-laying tractor is slow and it's designed to pull. A tank is fast and it's not a draft vehicle. The track is different and the power transmission is different. The tank must be designed to protect men inside from injury by jolting. The guns in a tank are not radically different from other guns, but the mounting is different, and difficult. To sum up, our officers said that tanks are complicated to build. But they added that they were pleased when American Car and Foundry started turning out tanks in one year after they started.

A 45-ft. propeller is reported in the works for the War and Navy air services. Best information says it will absorb 8,000 hp. at 800 r.p.m. Airplane men lifted their eyebrows when they first heard of this, "What for?" they said. But such a prop would have its axis only some 25 ft. from the ground, which is not fantastic at all when you consider the monstrous planes now being designed for Army and Navy.

Design by using models has its dangers as well as its advantages, the Navy's Bureau of Aeronautics has discovered. Back in 1938 when Martin was working up plans for 63 two-engine patrol bombers (XPBM-1), it looked like a pretty smart idea to have the company build a one-third size model capable of carrying a pilot aloft. Idea was that this would eliminate a lot of the changes that are always made in the design after the first full size ship is built. Unfortunately, the full-size plane behaved quite differently from the model. Extensive and expensive changes had to be made in the shape of the hull, and the Navy hasn't got delivery on its flying boats yet.

Turtlebacks for battleships, to ricochet shells from the air, seems to have been relegated to the popular mechanics library. Nobody will express an opinion as to whether it was a good idea, rejected by moss-back admirals, or whether it just won't work. Anyway, the program now apparently adopted is substitution of guns capable of both surface and anti-aircraft fire, instead of surface fire only. This change is going ahead rapidly on all ships.

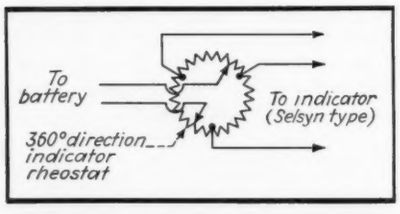
Inventors' clearing house. National Inventors' Council of the Department of Commerce, pictured here at its first meeting, has job of examining all ideas submitted on national defense, so as not to miss anything. The committee expects 99.9 per cent of intake to be "wacky," but doesn't forget that Morse, Goodyear, Ford and Fulton were once considered "screw-box" inventors. Left to right: Fred M. Zeder, Chrysler vice president; Dr. Fin Sparre, Du-Pont research director; Conway P. Coe, U. S. Patent Commissioner; Dr. Webster N. Jones, Carnegie Institute dean of engineering; Frederick M. Feiker, dean of George Washington School of Engineering; Dr. Charles F. Kettering, chairman of the Council; Lawrence Langner, patent lawyer; Dr. Thomas Midgley, Ethyl Gasoline vice president; Watson Davis, director of Science Service; Dr. William D. Coolidge, General Electric research director.

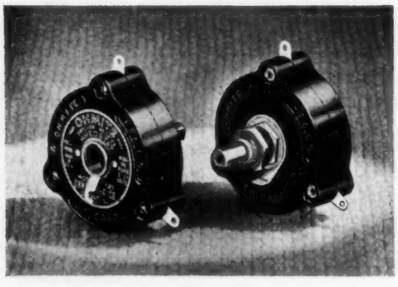
Harris & Ewing

New Materials and Parts

Direction-Indicator Rheostat

A compact, convenient device can be connected to the moving part of radio antennas, wind-vanes, valves, water gates, dampers and other apparatus in order to indicate the position of such equipment at a remote point. The rheostat unit has a 360 deg. continuous winding which is tapped at three points, 120 deg. apart. There are two moving contacts located 180 deg. apart, which are connected to a voltage source, maximum 24 volts. On installation, the rheostat shaft is coupled to the moving part by any convenient means which should be free from lost motion, and the three taps are wired to the delta-connected coils of a special 360 deg.

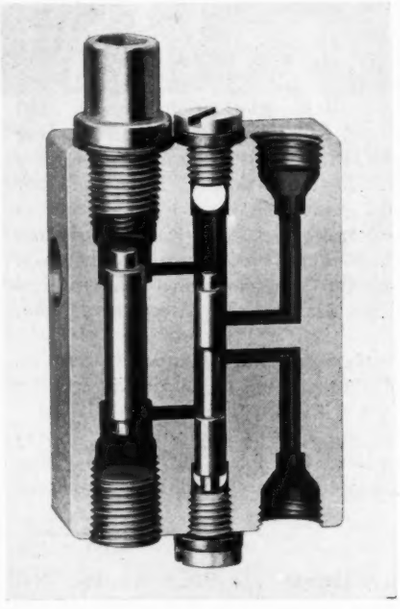




indicating meter of the direct current Selsyn type, or similar instrument. The unit consists of a glazed ceramic housing which is 1⅞ in. in diameter and 13/16 in. deep behind the panel. Shaft is ¼ in. in diameter. Ohmite Mfg. Co., 4835 Flournoy St., Chicago, Ill.

Centralized Lubrication

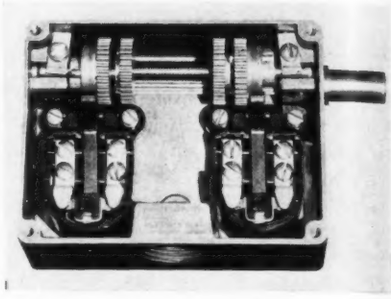
Dualine Jr. centralized lubrication unit operates on the same piston displacement principle of measurement employed in the large Dualine systems on heavy machines, but size has been greatly reduced to provide correct lubrication to small machine tools and other equipment. The new valve has but two moving parts. It contains no springs and no check valves and is fully adjustable. Positive delivery of the lubricant to each bearing is made



independently of the judgment of the oiler or his ability to reach all bearings regularly. Will deliver either oil or grease. Farval Corp., 3255 E. 80th St., Cleveland, Ohio.

Geared-Type Limit Switch

For applications on motor-driven devices where it is necessary to limit the rotation of the motor shaft or any rotating shaft or gear on the driven machine, new small-size geared-type limit switch is only $4\frac{11}{16}$ x $3\frac{1}{2}$ x $1\frac{33}{32}$ in. in size. In operation, the shaft of the switch drives a pinion shaft. The pinion shaft engages driving gears which move along the drive screw toward one of the operating gears. At end of travel in either direction, a pin on the traveling gear engages a pin on the operating gear. This causes the operating gear, cam, and safety pin, to rotate in a unit and move the switch contact arm to a high part of the cam, operating the contacts. Double-break, fine-silver contacts are designed for 125



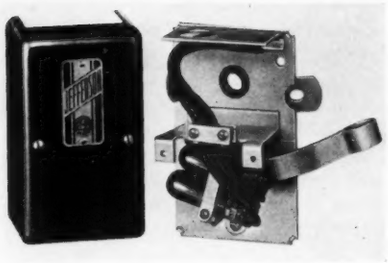
volts, 4 amp., a.c. operation, and 125 volts, 1 amp., d.c. operation. Mechanism can be adjusted to operate contacts between a minimum of ½ turn of the driving shaft to a maximum of 120 turns. General Electric Co., Schenectady, N. Y.

Protective Coating

New coating material, known as "Miccrolac" protects and beautifies metal surfaces of either natural or plated finishes. The material has a color approximating that of distilled water. It dries to a high lustre and is claimed to have excellent qualities of adhesion, flexibility and abrasion resistance. It dries exceptionally fast, the type of coat applied for ordinary decorative work drying in only a few seconds' time. It is resistant to sulphur dioxide, sunlight, moisture, oil, grease, gasoline, and all commonly known chemical fumes. It does not blush even in the most humid weather. It can be applied by spraying or dipping. If desired, it can be brushed on small parts. Available in 1-gal., 5-gal. cans and 50-gal. drums. Michigan Chrome Co., 6340 E. Jefferson Ave., Detroit, Mich.

Control Switch

This control switch, in which the circuit is made and broken inside ferrotube mercury contacts, can be operated by hand, by foot treadle, float or pressure in connection with signals, relays and similar devices. Design is simple, and the device is easy to install. It can be furnished with one mercury contact for single pole or a pair of contacts for double pole make and break,



or for controlling two separate circuits. Capacity up to 1,875 watts per mercury contact on circuits up to 440 volts a.c. and 250 volts for ¼ hp. a.c. split-phase motors, ½ hp. a.c. capacitor motors, and ¾ hp. a.c. repulsion motors. Jefferson Electric Co., Bellwood, Ill.

Photoelectric Relay Units

Photo-amplifier relay unit for use where relatively large amounts of light are available, and small independent light source which will throw a concentrated beam up to 50 ft., are compact, rugged, sensitive, and low priced new photo-relay units. A screwdriver adjustment is provided at the back of box of all photo-relay units to regulate the quantity of light necessary to operate the relay. Units are housed in sheet metal boxes with gray wrinkle finish, easily mounted. All units have double

output sockets, the bottom socket supplying power to operate any 110 volt device when the light is shown on the photo tube, the top socket supplying power when the beam is interrupted. Maximum rating of standard models is 300 watts controlled power for a.c. and 100 watts for d.c. Allied Control Co., Inc., 227 Fulton St., New York, N. Y.

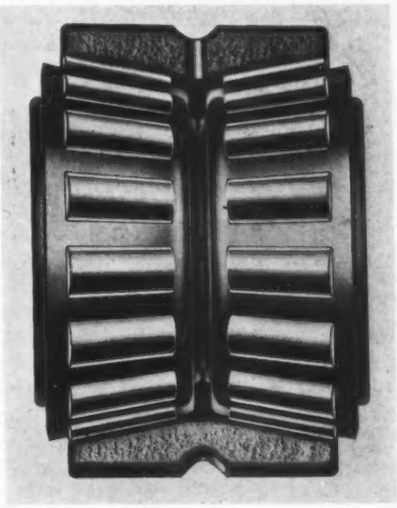
Whiteprint Machines

Featuring a new high pressure mercury vapor tube which uses 40 watts per in. and provides uniform distribution of light over the entire printing area, this machine will print up to 56 in. per min. This gives greater speeds at lower cost than have previously been available. The mercury vapor tube cuts electrical consumption as much as 50 per cent of that required by machines of equal capacity using arc lamps. The original and sensitized materials are brought into exposure by carrier belts which hold them against a 4¼ in. diameter pyrex glass cylinder. The cylinder is suspended at each end on three ball bearing rollers and revolves around the stationary high pressure mercury vapor tube by contact with the carrier belts. Hand con-

trol knobs conveniently located on the front of the machine permit adjustment of the printing speed. An adjustable light shade allows the operator to vary exposure within certain limits without changing the printing speed. Mechanically controlled ammonia vapors develop the exposed prints in the developer section of the machine. Ozalid Corp., Johnson City, N. Y.

Tapered Roller Bearing

Especially adapted to serve as a sheave bearing, this new design of the standard NA type, or non-adjustable, Timken roller bearing is made up of a double row outer race or cup and two single row inner races or cones. Races and rolls are ground to established precision limits so that when the cones are assembled into the cup the front faces of the cones contact and the proper running clearance is provided. Front cone faces are slotted and chamfered to provide entrance for lubricant. This feature is particularly advantageous in multiple sheave blocks where bearings must be lubricated through the pin. Chamfered front faces eliminate deep annular groove around shaft to carry the lubricant into the bearing. Bearings are designed to



a minimum width, with an I.D. large in relation to its O.D., and with maximum radial and thrust capacity for space occupied. Timken Roller Bearing Co., Canton, Ohio.

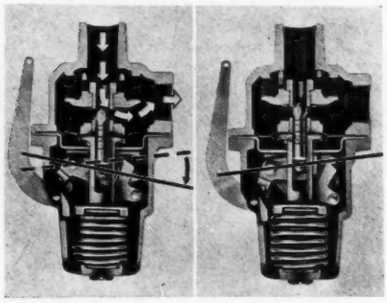
Bearing Metal

Bermax alloy, an improved lead-base babbitt for efficient, economical gasoline and diesel engine bearings and as a general purpose bearing metal is claimed to be used for a wide range of applications and offers substantial savings. It is so positioned in the lead-tin-antimony ternary system that the best compromise of desirable properties is effected. Its melting point is slightly higher than that of the tin-base metals and it can be cast by any method without fear of segregation. It is not brittle, and is not subject to oil corrosion. Bulletin available gives complete engineering description of Bermax, particularly with reference to its use in the automative field. Federal-Mogul Corp., Shoemaker & Lillibridge Sts., Detroit, Mich.

Safety Valve

Safety valve for hot water boilers, has a relief point of 29 lb. per sq. in. Its design departs sharply from usual construction in that the valve is designed to snap open to its full orifice capacity at the precise moment the relief point of 29 lb. is reached. It then stays open, discharging at full rate until the boiler

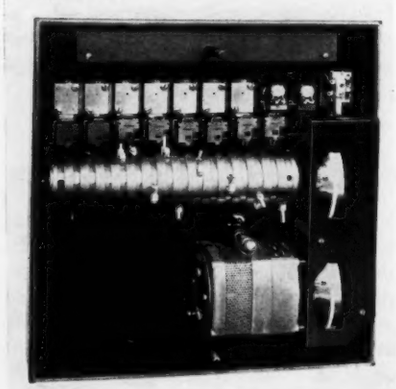
pressure is reduced to 22 lb., at which time it snaps to an instantaneous close. This snap action avoids the condition where a valve merely cracks at the relief point, permitting boiler pressure to build up to a dangerous level before discharge capacity becomes sufficient to reduce the pressure. From the illus-



tration, when the pressure acting on the bellows reaches 29 lb., per sq. in., the tip of the cam slides past the roller, permitting a lever to trip the valve wide open. The valve is of hardened stainless steel. Metal-to-metal seal above the cone protects working parts when valve is discharging. McDonnell & Miller, Wrigley Bldg., Chicago, Ill.

Timer

Adaptable for all-electric, all pneumatic operations, or combinations of both, the new Flex-O-Timer, permits maximum precision of timing with minimum labor and expense. Actuating pins on a revolving drum are easily and precisely adjusted in circumferential undercut grooves and locked in place with a screw. Cam cutting is eliminated. Pins actuate air valves or switches within ½ of 1 per cent of total cycle time. Timer motor is of the high torque, fan-cooled synchronous type. Drum is run directly by spur gear train, but a unique dog-and-latch mechanism provides 78 different drum speeds with



each gear train ratio. Drum speed is fixed and positive for any given setting and can vary only as the frequency of the electrical supply changes. For pneumatic operation, new type of air valve utilizes 99½ per cent of air passed through it. Air valve plunger is so designed that the air supply port cannot at any time communicate with the exhaust port, assuring rapid and full air pressure application and release. Dirt particles are sheared off by close fit of the piston, making the valves practically self-cleaning. Taylor Instrument Co., Rochester, N. Y.

Non-Magnetic Steel

A non-magnetic, free machining alloy steel possessing low magnetic permeability with superior mechanical properties has been developed especially for the electrical industry. It has a magnetic permeability of 1.003 to 1.006 at 1,000 Oersteds at temperatures from sub-zero to boiling. Illustration shows a piece of electrically magnetized iron

at the right and a piece of non-magnetic steel at the left. Another property of this steel is its high electrical resistance, 69 to 71 microhms per cm., which considerably reduces current eddy loss. In the annealed condition, the steel has a tensile strength of 80,000 to 110,000 lb. per sq. in.; yield point, 35,000 to 60,000 lb.; elongation in 2 in., 25 to 50 per cent; reduction of area 30 to 60 per cent; Izod impact value at room temperature, 80 ft. lb. The non-magnetic steel can be formed, welded, machined or blanked. Jessop Steel Co., 573 Green St., Washington, Pa.

Explosion Proof Micro Switch

Exposion proof housing of unusually compact dimensions, recently listed by the Underwriters' Laboratories, is designed to make use of the Micro Switch as the switching element. Listings are for atmospheres containing vapors of ethyl ether, gasoline, alcohol, acetone, lacquer solvents, and for grain dusts. Mounting space is kept to a minimum by omitting feet or lugs and providing a pair of holes on each of four sides. The switching unit inclosed within the cast iron housing is the standard precision Micro Switch with a separate Underwriters' listing of 1,200 watts up

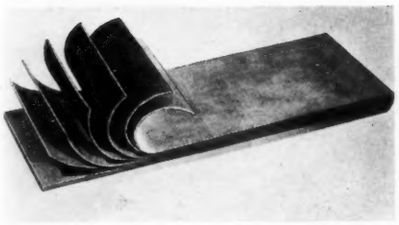
to 600 volts a.c. The switch can be easily removed for inspection or change. Types of actuation now available are the roller arm with the axis of the roller either parallel to or at right angles to the arm, and a bullet nose push rod type. Micro Switch Corp., Freeport, Ill.

Clear Lacquer

Clear lacquer that is especially suitable for finishing articles frequently handled, such as flashlights, pencils, compacts, and lipsticks, has been specially developed to resist corrosive action of perspiration. It is claimed to furnish excellent protection for both finished metal surfaces and undercoats of lacquer enamel. It is light in color and has good outside weather resistance, adhesion, and color retention. It is furnished in either high gloss or flat finish. Mass & Waldstein Co., 438 Riverside Ave., Newark, N. J.

Belting Material

Multiple, thin-ply construction of this new belt gives an extremely high flexing-ability, giving longer service without pulley or belt take-up. Fabco belt is made of a specially woven duck, weighing approximately 14 oz. to the square yard, which is thoroughly impregnated with a special rubber compound. The finished belt is of square edged construction. Belts are made in four weights and the minimum pulley diameters for these weights are: 5 ply, 4 in.; 6 ply, 5 in.; 8 ply, 7 in.; and 10 ply, 10 in. Belt is guaranteed against



ply separation on normal types of drives and up to speeds of 6,000 ft. per min. Available in any width up to 40 in. and in any length up to 275 ft.; endless belts as well as open length. Fabreeka Products Co., Inc., 222 Summer St., Boston, Mass.

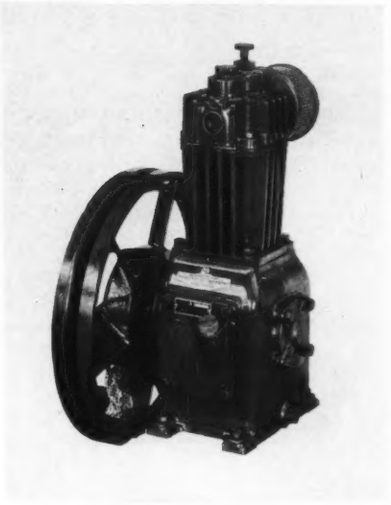
Manual Reset On Millibreak Switch

Manual reset device, now available with the normally closed, single pole, precision switch, comprises an insulated pin projecting from the Mu-Switch cover at the end opposite the actuating button. A momentary pressure of 4 oz. on the actuating button opens a contact circuit which remains open after the pressure is removed; a touch of the manual reset button re-

establishes the normally closed circuit. Besides its use as a safety device, the manually reset Mu-Switch is widely applicable as a simple, push type, on and off switch. Mu-Switch Corp., Canton, Mass.

Small Air Compressors

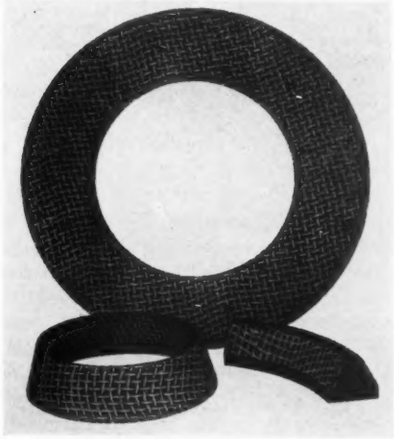
Known as the Type Q, these new small air compressor units are applicable for diesel starting, industrial and garage service. The units are air-cooled, single and two-stage, and range in capacities from 2.8 to 45.7 cu.ft. per min. Rated at ½ to 10 hp., for continuous operating pressures of 100 to 200 lb. per sq.in. and intermittent pressures of 150 to 500 lb. per sq.in. The compressors have cushioned air valves, balanced crankshaft, taper roller main bearings, Lynite connecting rods, semi-steel pistons, positive lubrication, copper inter-



cooler, chrome nickel cylinders and dust-proof crankcase. Automatic starting can be furnished. Available bare, base mounted or tank mounted, for V-belt drive from motor or air cooled gasoline engines. Sullivan Machinery Co., Michigan City, Ind.

Friction Material

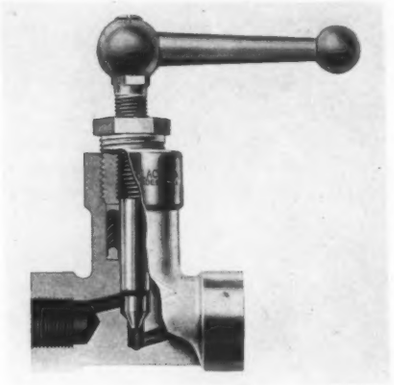
Asbestos friction material for brake lining and clutch facings, made with a unique combination of molded and



woven structures in proper balance to retain the best qualities of both, is claimed to give entirely new performance characteristics. Severe laboratory tests and hard service on a wide range of tough applications show that this material maintains a high frictional coefficient with good uniformity under widely varying conditions of load and temperature. On a number of particularly severe applications where service life of ordinary materials is but a few days, this new friction material is giving many months of trouble-free service. Available to accurate dimensions in all shapes and sizes for brake and clutch requirements. Gatke Corp., 228 N. La Lalle St., Chicago, Ill.

High-Pressure Needle Valve

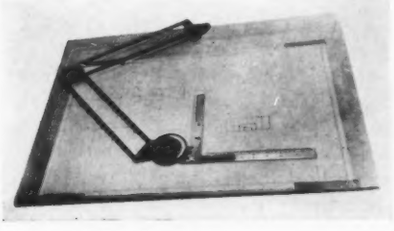
Designed to withstand oil pressures up to 10,000 lb. per sq. in. the Blackhawk V-8 valve can be used with any fluid not injurious to leather, bronze or stainless steel. Valve spindle is of stainless steel. Valve body is of high strength bronze. Packings are special



"chevron" type, with special spreader and oil channels. Pipe taps are ⅜ in. standard. Blackhawk Mfg. Co., Milwaukee, Wis.

Drafting Machine

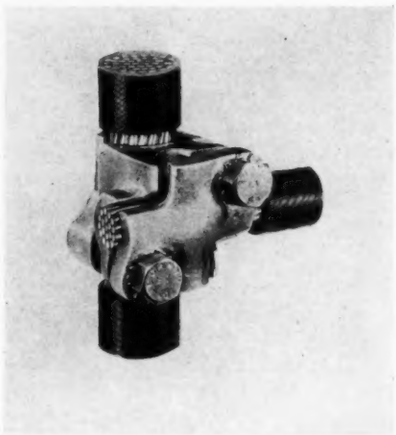
Completely adjustable ball bearing drafting machine is a precision instrument which can be clamped to any drawing board up to 2 in. thick and 36 in. wide. It has a hinged mounting, permitting it to be raised clear of the board. A leveling screw is provided to adjust the machine to the plane of the drawing board. Arms of Wrigraph Industro drafters are of specially rolled channel steel, giving great rigidity. All



steel parts are finished in black baked wrinkle enamel. Eight hardened ball-bearing assemblies are adjustable. A one-half deg. vernier equipped with a magnifier provides for a quick and accurate setting of all angles. The instrument was designed as a low-cost precision drafter. L. G. Wright, Inc., 5209-78 Euclid Ave., Cleveland, Ohio.

Electrical Connector

Type QPX connector can be used as a parallel tap, a T-connector, a cross connector or as an end-to-end connector and will clamp a large range and combination of cable sizes in either main or branch connection grooves. Compact, the Versitap can be readily taped and installed with an ordinary wrench. It is formed of high strength materials



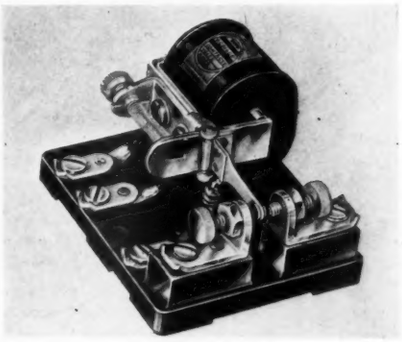
on parts which carry the mechanical stress and high electrical conductivity material on parts which transmit electrical current. Ten sizes accommodate cables from No. 8 to 1,000,000 circ. mil. Burndy Engineering Co., Inc., 459 E. 133rd St., New York, N. Y.

Steel Black Finish

Jetal process, whereby all steels except those of high nickel or chromium can be colored black with a corrosion and rust-resistant finish, has been improved to a two-bath system which yields a deeper black coating. Two tanks of ordinary iron or steel are required for Jetalizing. The first or "A" tank, should be kept at 280-290 deg. F., the second at 305-315 deg. F. After cleaning and the drag-out rinse, the wet work is placed immediately in the "A" tank and kept there until some coloration is noted. The work is then removed, rinsed in cold water and immediately placed in the "B" solution where it remains until the desired depth of black is obtained. The time required for the Jetal dips varies with the class of work, but in general, ranges from about 2 min. to 5 min. in each tank. Hanson-Van Winkle-Munning Co., Matawan, N. J.

Sensitive Relays

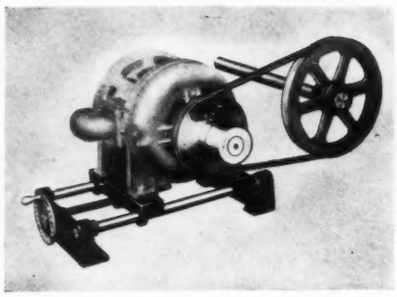
Claimed to be 50 per cent more efficient than any known sensitive relay, the new Circle relays are exceedingly



rugged and develop unusually high contact pressure and wipe. Relays are precision made and are assembled on a molded Bakelite base. Magnetic structure is of a special heat-treated alloy, and the hinge arrangement using a stainless steel pin with brass bearings assures long life under severe operating conditions. Coin silver contacts are rated for 1 amp. at 48 volts d.c. and 5 amp. at 110 volts, a.c. Available in both single and double pole, double throw. Relays are adjustable throughout. Allied Control Co., Inc., 227 Fulton St., New York, N. Y.

Speed Control

Any standard constant speed motor from fractional to 1½ hp. is easily and inexpensively converted into a variable speed unit by means of the new Reeves Vari-Speed Jr. The unit comprises a disk assembly and an adjustable motor base. The disk assembly consists of two cone-shaped disks (one stationary and one laterally adjustable), a self-adjusting tension spring, a spring adjusting nut and cover. The disk assembly is connected on the standard shaft extension of the motor and the motor is mounted on an adjustable base. An adjusting handwheel moves the motor forward and back, changing the pitch diameter of the adjustable pulley on which the V-belt drive runs. Speed can be adjusted while the machine is running. The unit is built in six different sizes



of disk assembly, and in two sizes of motor bases. It is also available in a countershaft type for requirements of either unusual speed reduction or speed increase. Reeves Pulley Co., Columbus, Ind.

Single-Phase Motors

A new line of single-phase vertical hollow and solid shaft motors, unusually adaptable for small pumping units. The frame, bearing brackets and inclosing covers give maximum protection against splashing water consistent with adequate ventilation. Even at speeds of 3,600 r.p.m. the motors are exceptionally quiet and free from vibration. Solid shaft units are available for direct-connection to a pump or machine through a flexible coupling. In the

installation of the hollow shaft unit, the pump shaft extends up through the motor shaft and is held in place by adjustable lock nuts above the upper motor bearing which is designed to support the entire thrust load. Fairbanks-Morse & Co., 600 S. Michigan Ave., Chicago, Ill.

Manufacturers' Publications

Materials

BRONZE—Koppers Co., Bartlett Hayward Div., Baltimore, Md. Leaflet BB-1, 2 pages, 8½x11 in. Engineering applications, recommended uses, and tables giving minimum physical properties of Koppers D-H-S bronze.

COLD-FINISHED BAR—Joseph T. Ryerson & Son, Inc., 16th & Rockwell Sts., Chicago, Ill. Bulletin, 8 pages, 8½x11 in. Gives complete description, chemical analysis, working properties, suggested applications and other interesting data on wide range of cold finished steel bars.

COLD-ROLLED STEEL—Crucible Steel Co. of America, 405 Lexington Ave., New York, N. Y. Folder CR100, 12 pages, 4x8 in. Gives data on cold rolled and cold drawn specialty steels. Weight of cold rolled spring steel, hardness conversion numbers and decimal equivalents are included.

ILLIUM—Burgess-Parr Co., Freeport, Ill. Bulletin 104, 8 pages, 8½x11 in. Giving complete information on Illium alloys, this bulletin has been brought up to date by the inclusion of corrosion test results.

PROMAL—Link-Belt Co., 307 N. Michigan Ave., Chicago, Ill. Book 1750, 24 pages, 9x11 in. Describes and gives complete engineering data on Promal for greater strength and longer wearing properties. Examples of applications are illustrated and described.

STAINLESS STEEL—Republic Steel Corp., Cleveland, Ohio. 4 pages, 9x11 in. Contains a table listing the analyses and properties of thirteen types of Enduro stainless steel, including approximate chemical compositions, physical properties, electrical properties and mechanical properties.

TUBING—Carpenter Steel Co., Welded Alloys Div., Kenilworth, N. J. Data book, 20 pages, 9x11 in. Setting forth the properties and methods of welded stainless tubing, this well illustrated booklet includes specifications of available forms presented in ready reference style.

Mechanical Parts

BRONZE BEARINGS—Bound Brook Oil-Less Bearing Co., Bound Brook, N. J. Stock List No. 1, 8 pages, 8½x11 in. Sets forth and lists complete stock of Compo oil-porous bronze bearings. Engineering data on permissible loads, shaft clearances and installations are included.

LUBRICATION—Farval Corp., 3255 E. 80th St., Cleveland, Ohio. Bulletin 10-A, 4 pages, 8½x11 in. Farval Dualine Jr. centralized system of lubrication is described in this bulletin, which includes engineering dimensions and diagrams and specifications. Tube fittings are also described.

OIL PUMPS—DeLaval Steam Turbine Co., Trenton, N. J. Catalog L-32-A, 12 pages, 8½x11 in. Illustrates and describes the DeLaval-IMO Oil Pumps, designed particularly for handling fuel oils, heavy crude oils, lubricating oils and hydraulic oils in capacities above 30 gal. per min.

SPEED INCREASERS — Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa. Booklet 3650, 24 pages, 8½x11 in. Describes complete line of Type SU speed increasers. Application data, specifications, complete dimension information and illustrated applications are presented.

SPEED REDUCERS—D. O. James Mfg. Co., 1120 W. Monroe St., Chicago, Ill. Catalog 17-A, 16 pages, 8½x11 in. Covering helical motorized reducers, this new catalog gives sectional views, dimension diagrams and selection tables which facilitate the selection of the proper motorized speed reducer.

TUBE COUPLINGS—Parker Appliance Co., 17325 Euclid Ave., Cleveland, Ohio. Wall chart lists, illustrates and gives specifications for combination and reducing tube fittings.

VARIABLE SPEED PULLEY—Speedmaster Co., 1301-7 Washington Ave., S., Minneapolis, Minn. A.S.T.E. Data Sheet, 4 pages, 8½x11 in. Describes technically the Speedmaster variable speed pulley and gives dimensional information.

Electrical Parts

CAPACITORS—General Electric Co., Schenectady, N. Y. Bulletin GEL-619, 8x10½ in. Folder illustrates and describes many applications of Pyranol capacitors.

ELECTRICAL CONNECTORS—Burndy Engineering Co., Inc., 459 E. 133rd St., New York, N. Y. Catalog No. 41, 64 pages, 8½x11 in. This well illustrated catalog contains engineering data on complete line of Burndy electrical connectors. The catalog is indexed and illustrated.

ELECTRICAL PRODUCTS—Colt's Patent Fire Arms Mfg. Co., Electrical Division, Hartford, Conn. Coltalog No. 3, 84 pages, 8¼x10 in. Illustrates and describes safety switches, Multi-Breakers, service equipment, fuses and a complete listing of sizes "0" and "1" new motor control units.

INSULATED WIRE—General Electric Co., Schenectady, N. Y. Bulletin GEA-2733D, 4 pages, 8x10½ in. Contains complete information on the many types of Flamenol wire now available. Its various applications are listed.

MOTORS—Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa. Descriptive data 3150, 4 pages, 8½x11 in. Describes Type CS totally-inclosed fan-cooled squirrel cage motors from 1 to 200 hp. Photographs and cut-away sectional sketches explain new heat exchanger principle.

MOTOR STARTERS—Colt's Patent Fire Arms Mfg. Co., Electrical Division, Hartford, Conn. Bulletin 504, 12 pages, 8¼x10 in. Complete descriptions with illustrations and engineering data of the new across-the-line type Colt magnetic motor starters, Colt overload relays and Colt push button stations.

PRECISION PRODUCTS—P. R. Mallory & Co., Indianapolis, Ind. Form M-770-A, 40 pages, 8½x11 in. Describes line of precision products, including switches, resistors, condensers, volume controls, and similar items.

Fabrication Methods

SPEED NUTS—Tinnerman Products, Inc., 2036-2046 Fulton Road, Cleveland, Ohio. Engineering Standards, 24 pages, 9x11½ in. Gives complete specifications for Tinnerman speed nuts, flat type, double flat type, W type, round type, U type, and J type. Sketches illustrate typical applications of these speed nuts.

Miscellaneous

FLUORESCENT LIGHTING — Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa. Booklet A-3618, 23 pages, 8½x11. This practical guide to application of Mazda F lamps and equipment includes illustrations of installations, wiring diagrams, and a table of essential technical data.

POTENTIOMETER-PYROMETER — J-B-T Instruments, Inc., 441 Chapel St., New Haven, Conn. Bulletin 540-70-PO, 6 pages, 8½x11. General description of the new Model 70-PO potentiometer-pyrometer is given in this booklet which lists typical applications.

TEMPERATURE REGULATORS — Sarco Co., Inc., 183 Madison Ave., New York, N. Y. Catalog 52, 16 pages, 8½x11 in. Covering self-operating temperature regulators for controlling flow of steam, gas, water, or brine, this well illustrated catalog includes capacity tables for several different valve styles.

THERMOMETERS—Brown Instrument Co., Wayne & Roberts Ave., Philadelphia, Pa. Catalog 6705, 6 pages, 8x10½ in. Sets forth features of complete line of circular case thermometers and pressure gages, indicators, recorders, and controllers, as well as self-contained and portable models.

WHITEPRINT MACHINE — Ozalid Corp., Johnson City, N. Y. Bulletin 187, 4 pages, 8½x11 in. Illustrates and describes main features of the new Ozalid Model F fast-printing whiteprint machine. Technical details are illustrated, and overall specifications are included.

Books and Bulletins

Practical Mechanics and Strength of Materials

CHARLES W. LEIGH AND JOHN F. MANGOLD—*Third Edition. 498 pages, 4⅞x7⅜ in. Blue clothbound covers. Published by McGraw-Hill Book Company, 330 West 42nd St., New York, N. Y. Price $3.*

In order to enlarge the scope and effectiveness of the book, a large amount of new material has been added in this third edition. Many illustrative examples have been included. All the lists of problems are new.

The volume is written to fill the needs of the practical man rather than for design engineers. A knowledge only of algebra, geometry and trigonometry is required to understand the theories developed, and to solve the problems presented. Graphic and algebraic solutions of the problems are presented together.

Chapters covering strengths of material are introduced with explanations of the principles of mechanics that are the basis of the development for each topic. Throughout the book mechanics and strength of materials are treated as one subject.

Metals

SIR HAROLD CARPENTER AND J. M. ROBERTSON—*In two volumes. 1,485 pages, 6x10 in. Blue clothboard covers. Published by Oxford University Press, 114 Fifth Avenue, New York. Price $35.*

These volumes cover in much detail metals and alloys that have industrial uses and applications, in an orderly and methodical presentation which correlates the factors having to do with properties, characteristics and technological treatment.

The treatise classifies the subject matter in six parts. Part one deals with the pure metals groups, in which their inherent characteristics, microstructure and crystal structure are described, including a discussion of how pure metals act in the presence of applied forces. Part two covers the metallurgical relations arising from the theory of alloys. Part three is concerned with the mechanical properties of metals and the degree of their resistance to oxidation and corrosion. Part four describes how the properties and characteristics of metals are affected by methods of heat and mechanical treatment. Part five deals with the industrial alloys based on iron, such as steel, alloy steels, cast irons and alloy cast irons. Part six is devoted to copper, aluminum, nickel, lead, zinc, tin, magnesium and their alloys.

Engineers who are interested in the industrial uses of metals, and also students of the subject, will find the data in this readable treatise to be a useful source of information for further study and a basis for development work.

Die Castings

ARTHUR STREET—*47 illustrations, 160 pages, 5x7½ in. Brown clothboard covers. Distributed by Chemical Publishing Co., 148 Lafayette St., New York, N. Y. Price $1.75.*

Published in England and therefore dealing largely with English practice, this book is a complete treatise of die casting. Presenting first the general considerations, Mr. Street devotes several chapters to a discussion on the choice of alloy wherein the various available types are described.

Of particular importance to design engineers, many chapters deal with the design of die cast products and dies, including considerations for cored holes, undercuts, inserts, threads, lettering and decorations, and assembly methods. Up-to-date plating and finishing techniques in England are also covered by Mr. Street.

Applied Mechanics

ALFRED P. POORMAN—*4th Edition. 354 pages, 6x9 in. Blue clothboard covers. Published by McGraw-Hill Book Company, 330 West 42nd St., New York, N. Y. Price $2.75.*

To obtain simplicity and better continuity several changes have been made in the arrangement of the material as presented in earlier editions. New material has been added in the chapter on moment of inertia of mass. Data in problems have been revised, and new problems have been added.

This text book defines the theories and laws of fundamental mechanics and shows their applications to the field of engineering. Part I deals with Statics. Part II deals with Dynamics. Major topics covered include forces, friction, centroids and centers of gravity, moment of inertia of areas and masses, kinematics, motion, work, energy, power, impulse, momentum and impact.

Distribution of Load On the Threads of Screws

J. N. GOODIER—*Reprint No. 8, 7 pages, 8½x11 in. Published by Cornell University, Engineering Experiment Station, Ithaca, N. Y.*

Reprinted from the *Journal of Applied Mechanics* for March, 1940, this bulletin reports the results of Mr. Goodier's research on load distribution on screw threads. By means of extensometer measurements on bolts and nuts, it is shown that the distribution is governed by (*a*) stretch and compression in bolt and nut, respectively; and (*b*) by bending of the thread, circumferential stretch, and contraction near the free end of the nut wall which have comparable effects in reducing the concentration.

It is evident, says Mr. Goodier, that any modification which increases any of the types of flexibility except simple axial strain, will have a favorable effect.

Food Mixer Motor Performance

C. S. SISKIND—*Engineering Bulletin 72, 41 pages, 6x9 in. Published by Purdue University, Lafayette, Ind. Price 25 cents.*

The purpose of this research project was to compare performance of motors used in food mixers. Most food mixers, which are coming to occupy a prominent place in the modern kitchen, use universal motors with armature speeds of 15,000-18,000 r.p.m. Nine such motors taken from mixers in all price classifications were chosen for testing, with rated input ranging from 75 to 150 watts. Tests were made to determine speed-torque characteristics, maximum speed, maximum torque, speed adjustability, a.c. and d.c. operation, and radio interference.

Results of the tests were quite astonishing in that they pointed out vast differences between one food mixer motor and another. Some motors proved to be absolutely ineffective in their speed adjustments. Some motors showed little speed variations between full load and no-load; others showed large differences. Some overheated dangerously; others didn't. Some had no radio interference; in some the noise was severe. One outstanding 150-watt motor, having approximately the same physical dimensions as the 75-watt motors, showed nearly 5 times the maximum torque of another motor with 150 watts input.

The author gives a brief analysis of the reasons for these differences, pointing out many factors of interest to designers of similar equipment.

HELICAL SPRING SELECTION CHART

A. C. RASMUSSEN
Indianapolis, Ind.

THE ACCEPTED FORMULAS for helical compression and tension springs with round wire can be reduced to simple terms involving functions of the spring factor $D/d = u$. These functions have been plotted in the chart given on the next page, so that once a spring has been tentatively selected, and the ratio D/d has been determined, the spring formulas can be applied with less computations and sufficient accuracy for most applications. The functions plotted are modified in accordance with the Wahl correction factor.

The simplified spring formulas are:

$$F = eys'$$
$$P = Md^2s'$$

where

F = total deflection in in.
e = solid height of active coils = nd
n = number of active coils
d = diameter of wire in in.
D = mean diameter of coil in in.
y = deflection per in. of solid height
P = load in lb.
s' = stress factor

The factors y and M are both functions of u, and are found from the chart. Since the chart has been worked out for an allowable stress of 100,000 lb. per sq.in., the factor s' in the formulas corrects for the given allowable stress by setting

$$s' = \frac{\textit{given allowable stress}}{100{,}000}$$

The quantity d^2 is tabulated below and weights are given for cases where costs or inertia are considerations.

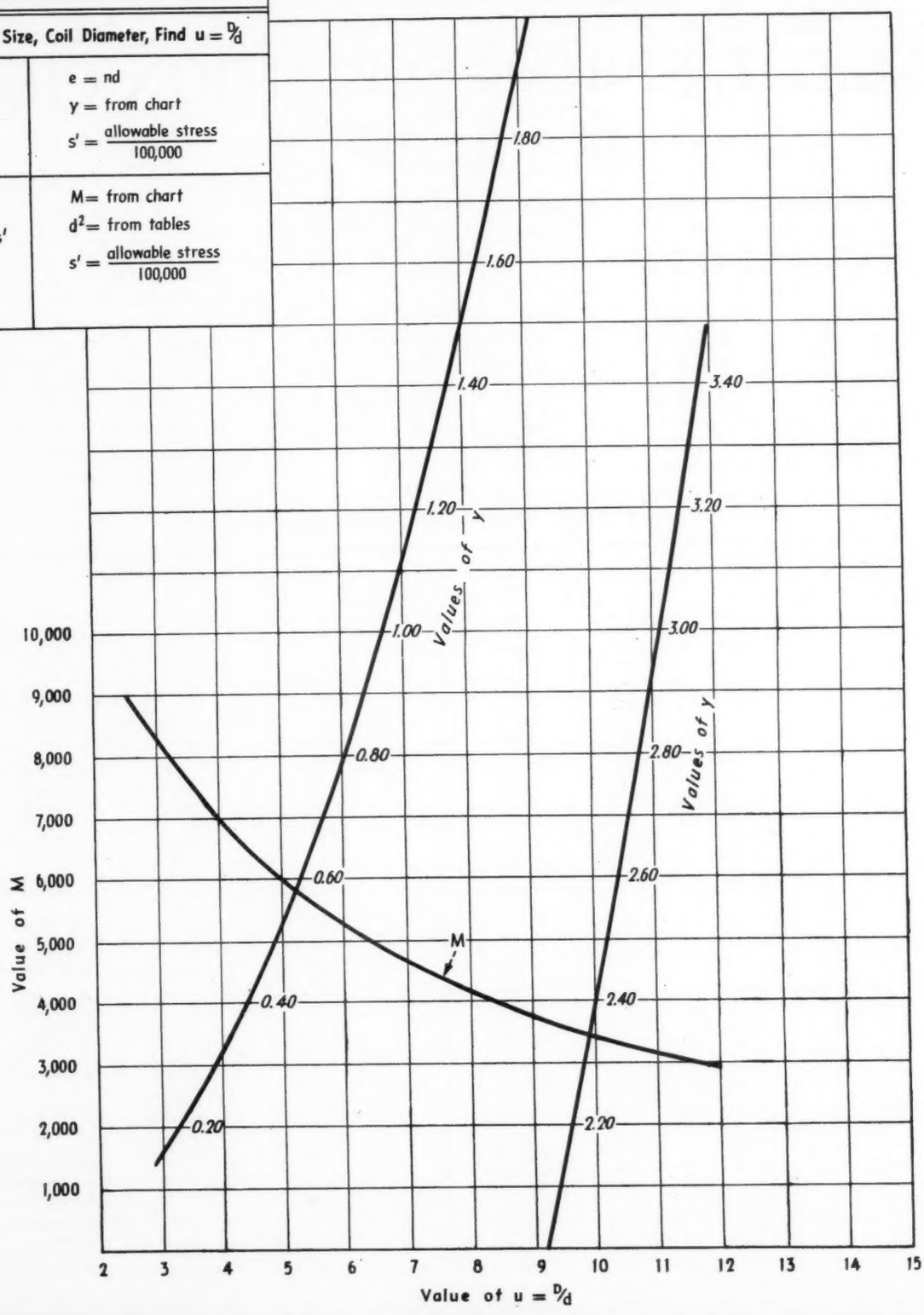
Spring Steel Wire—Diameters and Weights

Fraction Diam.	W. & M. Gage	Diameter d-in.	d^2	Wt. per ft. Lb.	Fraction Diam.	W. & M. Gage	Diameter d-in.	d^2	Wt. per ft. Lb.
1		1.0000	1.0000	2.6700		13	0.0915	0.008372	0.02236
15/16		0.9375	0.8789	2.3470		14	0.0800	0.006400	0.01709
7/8		0.8750	0.7656	2.0450	5/64		0.07812	0.006104	0.01630
13/16		0.8125	0.6602	1.7630		15	0.0720	0.005184	0.01384
3/4		0.7500	0.5625	1.5020	1/16	16	0.0625	0.003906	0.010430
11/16		0.6875	0.4727	1.2620		17	0.0540	0.002916	0.007787
5/8		0.6250	0.3906	1.0430		18	0.0475	0.002256	0.006025
9/16		0.5625	0.3164	0.8449	3/64		0.04687	0.002197	0.005867
1/2		0.5000	0.2500	0.6676		19	0.0410	0.0016810	0.004489
	7-0	0.4900	0.2401	0.6412		20	0.0348	0.0012110	0.003234
15/32		0.46875	0.2197	0.5867		21	0.0317	0.0010050	0.002683
	6-0	0.4615	0.2130	0.5687	1/32		0.03125	0.0009766	0.002608
7/16		0.4375	0.1914	0.5111		22	0.0286	0.0008180	0.002184
	5-0	0.4305	0.1853	0.5064		23	0.0258	0.0006656	0.001778
13/32		0.40625	0.1650	0.4407		24	0.0230	0.0005290	0.001413
	4-0	0.3938	0.1551	0.4141		25	0.0204	0.0004162	0.001111
3/8		0.3750	0.1406	0.3755		26	0.0181	0.0003276	0.0008748
	3-0	0.3625	0.1314	0.3509		27	0.0173	0.0002993	0.0007992
11/32		0.34375	0.1182	0.3141		28	0.0162	0.0002624	0.0007008
	2-0	0.3310	0.1096	0 2926	1/64		0.01562	0.0002441	0.0006519
5/16		0.3125	0.09766	0.2608		29	0.0150	0 0002250	0.0006008
	0	0.3065	0.09394	0.2509		30	0.0140	0.0001960	0.0005234
	1	0.2830	0.08009	0.2139		31	0.0132	0.0001742	0.0004653
9/32		0.28125	0.07910	0.2112		32	0 0128	0.0001638	0 0004375
	2	0.2625	0.06891	0.1840		33	0.0118	0.00013920	0.0003718
1/4		0.2500	0.06250	0.1669		34	0.0104	0.00010820	0.00028888
	3	0.2437	0.05939	0.1586		35	0.0095	0.00009025	0.0002410
	4	0.2253	0.05076	0.1356		36	0.0090	0.00008100	0.0002163
7/32		0.21875	0.04785	0.12780		37	0.0085	0.00007225	0.0001929
	5	0.2070	0.04285	0.11440		38	0.0080	0.00006400	0.0001709
	6	0.1920	0.03686	0.09844		39	0.0075	0.00005625	0.0001502
3/16		0.1875	0.03516	0.09388		40	0.0070	0.00004900	0.0001308
	7	0.1770	0.03133	0.08366		41	0.0066	0.00004356	0.00011630
11/64		0.17187	0.02953	0.07889		42	0.0062	0.00003844	0.00010260
	8	0.1620	0.02624	0.07008		43	0.0060	0.00003600	0.00009613
5/32		0.15625	0.02441	0.06519		44	0.0058	0.00003364	0.00008983
	9	0.1483	0.02199	0.05873		45	0.0055	0.00003025	0.00008078
9/64		0.14062	0.01978	0.05281		46	0.0052	0.00002704	0.00007221
	10	0.1350	0.01823	0.04867		47	0.0050	0.00002500	0.00006676
1/8		0.1250	0.01563	0.04172		48	0.0048	0.00002304	0.00006152
	11	0.1205	0.014520	0.03877		49	0.0046	0.00002116	0.00005651
7/64		0.10937	0.011960	0.03195		50	0 0044	0.00001936	0.00005170
	12	0.1055	0.011130	0.02972					
3/32		0.09375	0.008789	0.02347					

HELICAL SPRINGS—ROUND WIRE

Select Wire Size, Coil Diameter, Find $u = D/d$

$F = eys'$	$e = nd$ y = from chart $s' = \frac{\text{allowable stress}}{100{,}000}$
$P = Md^2s'$	M = from chart d^2 = from tables $s' = \frac{\text{allowable stress}}{100{,}000}$



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